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THE

MICROSCOPE

ITS REVELATIONS AND APPLICATIONS IN SCIENCE AND ART.

BY

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"I can truly affirm of myself, that my studies have been profitable and availing to me, only so far as I have endeavoured to use all my other knowledge as a *glass*, enabling me to receive more *light*, *in a wider field of vision, from the Word of God.*"

COLERIDGE.—Appendix to the *Statesman's Manual*.

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MDCCCLVIII.

" The Lord of all, Himself through all diffused,
Sustains, and is the life of all that lives.
Nature is but a name for an effect
Whose cause is God. . . . .
. . All are under One. One spirit—His
Who bore the platted thorns with bleeding brows—
Rules universal Nature. Not a flower
But shows some touch, in freckle, streak, or stain,
Of his unrivall'd pencil. He inspires
Their balmy odours, and imparts their hues,
And bathes their eyes with nectar, and includes,
In grains as countless as the sea-side sands,
The forms with which He sprinkles all the earth."

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PREFACE.

THE following pages have been written chiefly with a view to exhibit the bearings of modern Microscopic research on the elucidation of the minute works of the Creator, and the illustration thereby given of the Divine perfections.

It is well known that, in the present century, the advocates of infidelity have passed from the department of Metaphysics to that of Physics, in order to maintain their cause—not a little damaged on the former field of conflict—against Natural and Revealed Religion. In many cases, with a professed reverence for the wisdom, power, and goodness of God, as displayed in the Volume of Nature, there has been a subtle opposition to His manifestations in the Book of Inspiration; but between the Work and the Word of the Author and Lord of all, there can be no opposition. Humble inquirers, therefore, after truth, alike on the field of nature and of revelation, may anticipate, as the sure though perhaps slow result of such controversies, a more enlarged comprehension of the works of God in connexion with a clearer understanding of His Holy Scriptures. Already this issue has been seen. Do not the strange discoveries recently made at Nineveh and Babylon strikingly illus-

trate the Sacred Writings? And do not these in return reflect the brighter light of the inspired page on Nineveh and Babylon—these old enemies of Heaven's cause—when they arise from their deep graves, after the silence of three thousand years, to emit their testimony before the world? For a time, too, not a few hoped that the Geology of our century would give the final death-blow to that Bible, which, for thousands of years, has maintained its place as the Creed of nations. But already Geology has been found to supply the most cogent and complete refutation of Hume's boasted argument against miracles; and perhaps the time is not far distant when it will appear that such works as the *Testimony of the Rocks*, or *Sermons in Stones*, will prove a closer agreement between the first page of Scripture and the many pages of the Earth's successive formations, than the most ardent advocate of Inspiration could, until recently, have hoped ever to discover.

The conflict has extended to the field of Physiology; and here, too, the friends of religion may anticipate an equally triumphant issue. The Microscope will certainly contribute its aid in no small degree to the result, as it reveals to us the (otherwise) "invisible things of God" in His minutest operations, and proclaims that "*there* was the hiding of His power."

March 18, 1858.

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ERRATA.

Page 2, line 11, for *at only* read *only at.*
In pages 27, 36, and 37, for *Desmidiæ*, read *Desmidieæ.*

CHAPTER I.

MODERN INVENTIONS AND THEIR RESULTS.

1. THE age in which we live teems with the marvellous inventions of man. The early fruits of these inventions warrant us in anticipating from them, as they advance to maturity, the greatest and most beneficial changes upon society, art, and commerce, throughout the world. We see Watt's steam-engine, with its gigantic arm, guiding the manufactures of millions along the great highways of the land, and resistlessly conveying the commerce of nations along the greater highway of the deep. We everywhere see our countryman's noble invention regulating the ten thousand looms of our manufactories, ploughing the deep strata of our firm-set soils, reaping the golden grain of our wide-spread

fields, or gathering far beneath our feet the not less precious harvests of our coal, and lime, and iron mines: and as we gaze on the strange and varied scene, we are constrained to ask, Where is the seer's eye that can yet discover, or the prophet's tongue that can tell, what is to be the amount of the changes that the world is destined to witness, as the result of the invention of the Steam-Engine?

Or we see the Electric Element, that for six thousand years seemed to go forth at only Heaven's bidding, and to flash before the human eye as the most awful of God's material agencies, at last arrested in its dread path, and employed by the genius of a Wheatstone to pass on its way as man's most ready and rapid messenger, —communicating his thoughts with a tongue of fire, in a moment of time, in the twinkling of an eye, to his brother man, at the ends of the earth;—now conveying to us war's dread tidings from the shores of the Crimea, or the wide-spread plains of India; and now preparing to circulate daily and instantaneously between the Old and New Worlds—even though the deep and stormy waters of the Atlantic roll between them—the

hourly transactions in the Exchanges of London and New York. And with the results of this one invention, ever and anon more and more marvellously revealed, we may again unhesitatingly inquire, Who will venture to set bounds to the changes which may ensue over our globe to its farthest limits, and throughout its unnumbered families, from the Electric Telegraph? As we contemplate such inventions, and attempt to anticipate their results, we are called to form a still more elevated conception than we had previously entertained, of the genius of man, by whom such powers of nature have been discovered and controlled, and to raise a new song of praise to that God whose "inspiration giveth men understanding."

2. But there are other most valuable inventions of recent days, which society at large is not so ready to remember; perhaps, because they stand less closely connected with the daily pursuits and material enjoyments of the world. To these inventions, it may be alike profitable and pleasant often to turn our thoughts; and that the more, because, even in a still higher degree than in the cases already noticed, they tend to

exalt our ideas of the genius of man, and to enlarge our views of the glory of our Maker. Chief among these inventions we venture to class the Telescope and the Microscope. What worlds, vast beyond conception, and by human eye previously altogether unseen, have been brought to view by the Telescope, as, in the hand of a Newton or Rosse, this instrument has swept the face of the sky ; or, as directed by the mind of the English Adams, or the French Leverrier, it has revealed a new planet, dwelling up to that moment beyond the ken of man in the remotest distance of the limitless universe, and thus achieved a discovery more wondrous, if possible, than when Columbus sought and found a new world beyond the Atlantic wave !

3. Not less marvellous than the Telescope is that other instrument which we have named, and to which our attention is now to be more specially directed ; the *Microscope*, which reveals to us the minute worlds which lie ever near and around us, and which but for its use would never have been disclosed to our view. It is indeed hard to say which of these two instruments, the Telescope or the Microscope, has

most fully evidenced the powers of man, and most clearly illustrated the perfections of God. For the universe which the Microscope subjects to our ken seems as boundless in its very minuteness, as that other universe which, in its magnitude, still eludes the far-searching glance of the Telescope.

4. When declaring the care of the Almighty and the Infinite One for the smallest as well as the greatest of His creatures, and marking the singularly gracious providence by which the Telescope and the Microscope, that revealed alike the mightiest and the minutest of God's worlds, were invented about the same time, Dr. Chalmers, with equal truth and beauty, says of these instruments:—"The one led me to see a system in every star—the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and of its countries, is but a grain of sand on the high field of immensity. The other teaches me that every grain of sand may harbour within it the tribes and the families of a busy population. The one told me of the insignificance of the world I tread upon—the other

redeems it from all its insignificance ; for it tells me that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless as are the glories of the firmament. The one has suggested to me, that beyond and above all that is visible to man, there may lie fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the universe. The other suggests to me, that within and beneath all that minuteness which the aided eye of man has been able to explore, there may lie a region of invisibles ; and that, could we draw aside the mysterious curtain which shrouds it from our senses, we might there see a theatre of as many wonders as astronomy has unfolded, a universe within the compass of a point so small as to elude all the powers of the microscope, but where the wonder-working God finds room for the exercise of all His attributes, where He can raise another mechanism of worlds, and fill and animate them all with the evidences of His glory."[1]

[1] Dr. Chalmers's *Astronomical Discourses*, Disc. iii.

5. If the state of science forty years ago justified these glowing reflections, what language would the matchless writer have employed to depict the progress of discovery, through the aid of the Microscope, in our day, and to enforce the arguments thence arising for the presence of God in all His worlds, and His care for all His works! Forty years ago the Microscope was comparatively but a mere "toy;" its capabilities of being advanced to its present perfection were not anticipated; and still less were its recent discoveries dreamt of, even by the most sanguine of those who sought its assistance in their researches. This instrument had been for two centuries in the hands of the most gifted students of nature, but still a thick and apparently impenetrable veil wrapped in deep obscurity many a world of exquisite variety and beauty, that had been lying all undiscovered under the eye of man, or had been trodden under his foot at every step he took in the journey of life! The most favoured of nature's explorers stood only in the outer court of her temple, seeing through a cloud darkly; and over the gate by which he strove to penetrate

to the inner sanctuary, the irrevocable sentence seemed to be written, "Hitherto shalt thou come, and no farther." Now, through the use of the instrument in its more perfect form, the curtain has been raised, the veil has been rent asunder, a way into the inmost shrine has been opened up, and the observer may, with mingled reverence and joy, behold many of the deep mysteries of nature for the first time unfolded to his view. Here, indeed, the humble grateful observer may regard himself as standing on awful ground; and he may hear proclaimed to him, by the voice of nature, lessons at least analogous to those delivered to the high-priest as he bowed his head once a year before the mercy-seat, in the special dwelling-place of the God of Israel, in the Holiest of all. Of old the high-priest standing on this sacred spot—surrounded by its dread mysteries—looking in faith to the rod that budded, and the manna that had fallen from heaven, then lifted his eyes to the mercy-seat, and ventured to gaze even up to the brightness of the Shechinah itself, and so received from the Holy One the precious pledge, that God the Lord, who had

made that rod to bud in Aaron's hand, and blessed that manna—that "little thing"—to nourish the thousands of Israel, would ever be Israel's Guide, and Guardian, and God. So the observer of nature, now permitted to enter the hitherto untrodden and unseen court of her temple, as he sees her strangest mysteries revealed to his view;—as he beholds the amazing expenditure of wisdom, and power, and goodness, on the minutest objects of the Divine workmanship;—as he looks upon the tiny insect, that ages ago fluttered away its brief existence in a few hours, still preserved—after the lapse of ages—in all the exquisite perfection of its structure; or as he surveys the organism which at the distance of millions of years may have found its dying bed in the bosom of that flinty rock, and yet remains to this day—after an ordeal, perchance, of many floods and fires—with its gorgeous shield of elaborate carving and delicate tracery all unscathed,—here stands confronted with over-awing and overwhelming evidences, even from the very least and lowest of organized beings, of the being and perfections of the Omnipresent, Omnipotent, and Omni-

scient; and here finds a new and mighty illustration of the blessed truth, that God regards no portion of His universe as too minute for His notice, and no creature of His hand as too humble for the visitation of His care. And shall not God—the God who so formed that insect, and so preserved that organism—the God who feeds the fowls of heaven, and adorns the lilies of the field—shall not He much more keep and care for, bless and save His people, and be their Father, and Friend, and God, for evermore!

6. Let us now proceed to examine more specially the instrument by the use of which these discoveries have been achieved—the *Compound Achromatic Microscope*. It is called *Compound*, from more than one lens being employed; and *Achromatic*, or without colour, from being so constructed as by a combination of lenses to bring the light, broken by one lens into various rays of different colours, to be re-collected, or nearly so, by another lens, in such a way that the object to be viewed is seen in a distinct and full light. In the Compound Microscope, at least two compound lenses must be employed;

one to form the enlarged image of the object, and which, from being nearest to the object, is called the Object-glass; while the other lens magnifies that image, and, from being placed between it and the observer, is called the Ocular, or Eye-piece. In good Compound Microscopes, a greater and more varied combination of lenses is used, both for the object-glass and the eye-glass; by means of which, according to the power used, any object under the glass may be magnified in lineal measure from a small degree up to 2000 times (or diameters); or, if we calculate this superficially (including breadth as well as length), up to 2000 × 2000, or four million times.[1]

7. The Compound Achromatic Microscope, as we shall presently see, is the invention of a very recent period. The Single Microscope, as it may be called, is nothing more than a convex lens, having generally a short focal distance. The earliest convex lens that we have any knowledge of was brought recently from the East. Among the strange fruits of Layard's

[1] To make these statements thoroughly clear, and some of the succeeding illustrations fully intelligible, diagrams would be necessary.

labours in the midst of the ruins of old Nineveh, not the least singular was the discovery of a plano-convex lens of rock crystal. "Its properties," says the distinguished discoverer, "could scarcely have been unknown to the Assyrians, and we have, consequently, the earliest specimen of a magnifying and burning glass."[1] Seneca, in the first Christian century, alludes to the magnifying power of a glass globe filled with water, and thus rendering the smallest letters of the alphabet larger and more distinct.[2] But at this time lenses of glass were chiefly used as burning or reading-glasses, and it was only about the beginning of the seventeenth century that even the simple Microscope was used to enter upon the field of those great discoveries, which the more elaborate Compound Microscope has effected in our day.

As in many other cases, it seems now impossible to name any one individual, to whom, above his fellows, belongs the honour of inventing the Single Microscope. Some claim it for Roger Bacon, in the thirteenth century; and

[1] Layard's *Nineveh and Babylon*, p. 197.
[2] *North British Review*, August 1856.

he is said to have exhibited, by the use of a particular glass, such extraordinary appearances at Oxford, as to have gained the reputation of dealing with the powers of darkness. By others, again, the claims of natives of Italy, Holland, and Germany, have been respectively advanced; and, perhaps, all of them may now be justly allowed to share the honour. In the year 1621, a Compound Microscope was certainly used in England. It was a very different instrument, however, both as to appearance and power, from the present Compound Microscope; for the instrument then bearing that name is said to have been about six feet long, and only an inch in diameter; its tube was of gilt copper, resting on brass and ebony, and adorned with figures of ebony. It was, in fact, much more like the Telescope, than the Microscope of the present day. About the end of the seventeenth century, this instrument was constructed after a form scarcely less remarkable; one having been made at Rome nearly a foot and a half long, as thick as a man's thigh, and having an eye-glass as large as the palm of a man's hand. Many and great changes, with corresponding

results in new discoveries, were successively made on the instrument; Sir Isaac Newton himself not deeming it beneath his transcendent genius to lay down the Telescope, and turn away from the contemplation of sun, and moon, and stars, in order to use the Microscope for the purpose of advancing it to greater perfection, and of prosecuting the study of the minute worlds which it revealed to the eye of man.

8. But though the Microscope had been employed in the study of nature by many of the most distinguished in the land for two hundred years, and though important discoveries had been made from time to time, the instrument, as has been justly remarked, was little more than "a scientific toy," until about the year 1820. Up to that period, two great difficulties prevented the development of its powers. We will attempt briefly to state these difficulties, and to explain the methods employed for overcoming them. Those who are even slightly acquainted with the science of optics, are aware that rays of light, transmitted through a lens, are differently affected in the passage. Some rays are more, some less, refracted. The rays that

pass through the peripheral portion of the lens (or near its outer edges) are more refracted than those which pass through the central portion of the lens; consequently, all the rays do not come to the same focus, and the object of vision is less distinctly seen at the focus. This is called *Spherical Aberration.* This difficulty has been obviated by making use of a combination of lenses of different forms (convex and concave), by which their several aberrations correct each other, and bring the rays of light to one and the same point, thus placing the object to be viewed in the focus of the now combined rays of light. A second difficulty remained to be removed. It is known that rays of different colours make up *white*, or colourless light. These rays possess different degrees of refrangibility, and this difference causes them, passing through a lens, to come some to one focus, some to another. This is called *Chromatic Aberration.* This difficulty is overcome by a combination of lenses of a *different density, flint-glass* and *crown-glass* affording the materials for their construction. These lenses correct each other; bring the different coloured rays to the same

focus, and present the object that is to be viewed in a perfectly colourless, or white light. Unimportant as this improvement may seem to us, it baffled the most eminent men of science to accomplish it until within these twenty-five years. "When it is considered," says Dr. Carpenter, "that in the highest powers now made, the largest of three pairs of lenses is very little larger than a pin's head, and the smallest much smaller than a pin's head, we can easily understand the difficulty of producing the required achromatic corrections in these cases, and admire the marvellous mechanical skill to overcome in such a space the difficulty of chromatic aberration."

9. How important the results flowing from the invention of such lenses! Through an opening, large as the prick of a pin might make, they revealed to us new worlds, and the extraordinary structures of many of the most delicate and beautiful objects in nature. What Young said of the human eye, we may well apply to the Microscope, which

> "Takes in at once the landscape of the world
> At a small inlet, which a grain might close,
> And half creates the wondrous world we see."

Who, indeed, can anticipate the discoveries that may still be made of the great and marvellous works of God through the use of this little instrument! Our own gifted countryman, Sir David Brewster, to whom the Microscope owes so many of its excellencies, and who, above all others, is entitled to speak of its future possible performances, hopes that lenses of still higher power than any now used may be obtained, from employing, in their formation, fluids or diamonds, instead of glass, as at present; and thus writes, in his recent article on the subject in the last issue of the *Encyclopœdia Britannica*:—"The Microscope promises to be the means of disclosing the structure and the laws of matter, and of making as important discoveries in the infinitely minute world as the Telescope has done in that which is infinitely distant."[1] By some, it is indeed maintained that the Microscope has already attained, as regards its structure, the highest possible excellence. Mr. Quekett and Dr. Carpenter, two of the greatest authorities in England, have recorded it as their decided opinion that the Compound Achromatic Microscope is the most

[1] *Encyclop. Brit.* Art. *Microscope*, vol. xiv. p. 763.

perfect of instruments. "These Microscopes," says Mr. Quekett, speaking of those made by our first-rate opticians, Ross, Powell, Smith, and Beck, "approach, as far as we can judge at present, the limits of conceivable perfection."[1] "The Microscope," says Dr. Carpenter, in his elaborate treatise published in 1856, "has acquired the deserved reputation of being *one of the most perfect instruments* ever devised by art for the investigation of nature."[2] Notwithstanding these very positive assertions, we would be exceedingly loath to forego the hopes which Sir David Brewster allows us to cherish of still higher progress towards perfection in the future of the instrument. We may remember, for our encouragement, that so late as 1821, M. Biot regarded "the introduction of *achromatic* object-glasses *as out of the question*, from the impracticability of making achromatic lenses as small as those which the microscope requires."[3] But this object has been triumphantly attained.

[1] Quekett's *Practical Treatise on the Microscope*, p. 67.
[2] Carpenter's *Microscope and its Revelations*, p. 10.
[3] *Encyclop. Brit.* Art. *Microscope*, vol. xiv. p. 777.

CHAPTER II.

EARLY DISCOVERIES BY THE MICROSCOPE.

1. WHAT have been the applications and the discoveries of the Microscope?

"Of all the instruments which have yet been applied to scientific research, there is certainly none whose use has been more largely or more rapidly productive of most valuable results," than the Microscope. There is scarcely a region of the world, or an element of nature—scarcely an art or science—scarcely an atom of unorganized matter—scarcely a thallogen or acrogen—scarcely a sea-weed or fern of the Silurian or Red Sandstone systems, onward to the loftiest dicotyledon of our own forests and gardens—scarcely an organ or tissue of animal, from the humblest crustacean or mollusc up to man "monarch of all,"—upon which the Microscope has not fixed its clear far-searching eye, and by which it has not triumphantly proved its

powers. Thus in all, and from all, creatures around us, the instrument finds ever new illustrations of the infinite variety and exquisite perfection of the forms of matter, and so leads us to the best and highest of all science. It tends to enlarge our minds with the knowledge, and fill our hearts with the adoration and love of that awful Being, who has left the impress of His perfections, the proof of His presence, and wisdom, and goodness, and power, everywhere and in all things, throughout the vast of all past ages, and of all surrounding space.

2. Selection and condensation in the prosecution of our remarks are here all the more difficult, from the very extent of the field of inquiry, and the variety of illustrations that we might adduce. But let us so far attempt to show how the Microscope reveals to us the marvels of the earth beneath our feet, and of the waters around us, and of the heavens above —the new worlds that exist in the clouds of the sky, in every dust of the flower, in every drop of river or ocean, and in every atom of sand upon which we tread. Look back, then, one hundred years.

3. About 1750, M. Trembley of Geneva gave to the world his researches on the Fresh-water Polype, or Hydra. The results were alike unexpected and astounding. It seemed as if a new continent, with a new and hitherto utterly unknown race of inhabitants, was starting into existence. The facts were so extraordinary, as to appear to contradict the experience of all former ages, and to overturn some of the most established notions of animal life. Even the scientific world was amazed, and its members passed through all the various processes of dogmatizing, disbelieving, denying, ridiculing, wondering, hesitating, doubting, believing, until at length the conclusions of M. Trembley were fully confirmed and universally admitted. "We are now so familiar," says a distinguished naturalist, "with the outlines of the history of the fresh-water polype, and its marvellous reproductive powers, that we can scarcely appreciate the vividness of the sensation felt when it was all novel and strange; when the leading men of our learned societies were daily experimenting on these poor worms, and transmitting them to one another from distant countries by

careful posts, and as most precious gifts; and when even ambassadors interested themselves in sending early intelligence of the engrossing theme to their respective courts."[1]

The discoveries of Trembley may still be regarded as a most important epoch in the history of Microscopic inquiries. Up to that time the Hydra had been classed with *plants*, but it was then found to be a *true animal*. It presented, moreover, quite *a new type of animal life*. For it was immediately ascertained that it could propagate itself by buds like a plant; that it could produce afresh any part that might be cut away; that if cut across the upper part, it would produce a new body and tail, and the lower part as rapidly produce arms and head; that if the head was divided, each portion would provide for itself the wanting part; that if minced into thirty or forty pieces, each piece would grow into a new and perfect polype; and that if two individuals were *grafted together* head to head, or tail to tail, or the head of one to the tail of another, still the animal economy would be complete as ever: Ay, more

[1] Johnston, *Brit. Zooph.* p. 126.

wonderful than all, it was found that this extraordinary creature could endure to be turned inside out like a glove, so that what had been outer skin should become stomach, and the lining of the stomach become the outer covering or skin; while, from all this cutting and dissecting, grafting and transforming, the animal itself seems to suffer not the slightest inconvenience, being apparently blessed with exemption from everything like bilious attacks or stomach complaints in that department of the body from which so many of man's ailments arise! However happily Dryden's famous description fitted a versatile character of old,—

"Was everything by starts, and nothing long,"

it might in some respects be as truly applied to this very curious little gentleman, the Freshwater Polype, or Hydra. Trembley gives us the following episode in the life of these strange beings, which alone would stamp them with the mark of singularity:—On one occasion, he tells us, two hydræ, one stronger than the other, had seized a worm; neither would let go its hold of the prey, and each went on devouring it. As the victim disappeared, it soon be-

came evident that, as in the case of many a nobler conflict, a collision would ensue between the allies in the process of destruction. The collision came, and at length the stronger hydra made short work of it with his rival; for he not only swallowed the small worm, but its destroyer on the opposite side of the field of battle. It might be expected that this tragic occurrence would put an end at least to one of the combatants, that the curtain had finally dropped upon the scene, and that over the strange grave of the departed the inscription might now be recorded—"*De eo actum est!*" "*It is all over with him!*" But not so; for, after an imprisonment of an hour or so in this novel dungeon —the stomach of its antagonist—the smaller Hydra marched forth, if not with all the honours of war, at least without apparent serious injury. As boys, we have all wondered and laughed at the old story of the water-serpent, the Hydra of the marsh of Lerna; but how often, in after-life, are we reminded that the realities in God's works are more marvellous than all the romance of fable!

4. Let us pass over the Microscopic history

of nearly one hundred years, and come down to 1839. In that year, Professor Ehrenberg of Berlin announced the astounding tidings that he had discovered, beneath the foundations of his own city of Berlin, a widely-extending bed of earth teeming with living organisms. The name *Infusoria* was first given to this newly discovered race, because it was supposed that they were chiefly to be found in infusions of vegetable or animal matter. It is now understood that this name, though still retained as a *general* designation, is not, on the above account, thoroughly appropriate, as the infusoria are found not merely when there is an infusion of vegetable or animal substances, but wherever there is water.

5. Ehrenberg still regards these creatures generally as animacules, but many microscopists deny this name to these organisms, and class them with *plants*. In this, and in other analogous cases, Professor Carpenter's remarks may be carefully borne in mind. "The boundary between the two kingdoms" (animal and vegetable) "is not less keenly debated among naturalists than that of many a disputed frontier

has been between adjacent nations. For many parts of this border country have been taken and retaken several times ; their inhabitants having first been considered on account of their general appearance to belong to the vegetable kingdom ; then, in consequence of some movements being observed, in their being claimed by the zoologists ; then, owing to the supposed detection of some new feature in their structure or physiology, being again claimed as members of the animal kingdom; and, lastly, on the discovery of a fallacy in these arguments, being once more laid hold of by the Botanist, *with whom, for the most part, they now remain.*"[1]

Professor Carpenter further remarks, that the most generally applicable test to distinguish between any organism of the animal and vegetable kingdom, "*is not*, as was formerly supposed, *the presence or absence of spontaneous motion*, but the dependency of the being for nutriment upon *organic compounds* already formed, which it takes, in some way or other, into the *interior* of its body ; or its possession of the power of obtaining its own alimentary

[1] Carpenter on the *Microscope*, pp. 262, 263.

matter by absorption from the *inorganic elements on its exterior*. The former is the *characteristic* of the *animal* kingdom as a whole; *the latter is the attribute* of the *vegetable*."[1]

In the application of his definition, Dr. Carpenter would very much restrict the old term *Infusoria*, banish the term *Polygastrica*, and class the *Desmidiaceæ*, *Diatomaceæ*, *Volvocineæ*, &c., as *Protophytes*. Mr. Pritchard, again, contends that many of the groups which have recently been regarded as *plants* are *true animals*. Thus, speaking of the Volvocineæ, he states, in his work on *Infusorial Animalcules* (p. 153, 1852), that "*his own observations, continued through twenty-five years, induce him firmly to believe in the animal nature of these organisms.*" *But it seems generally ruled* by the ablest naturalists, that Messrs. Ralfs and Smith have decisively proved—the former in his work upon the *Desmidiæ*—the latter in his work upon the *Diatomaceæ*—that both groups must be reft from the Animal kingdom, in which Ehrenberg would range them, and placed in the Vegetable. In consequence, however,

[1] Carpenter on the *Microscope*, p. 263.

of the conflicting theories on these points maintained in the past, the various designations above referred to may be used and interpreted with considerable latitude. Microscopic inquirers, too, must take care to pursue their future researches with care and diffidence; while from those differences of opinion among the members of the Microscopical, of the Geological, and of other schools in the kingdom of Nature, the student of the Inspired Word may be the more stirred up to thank God that, in the kingdom of grace, we have "His Oracles"—the "more sure word of prophecy, whereunto we do well that we take heed, as unto a light that shineth in a dark place."

6. In 1839, as we have said, Ehrenberg discovered a world of organized beings beneath the streets of Berlin, and gave to them the name *Infusoria*. They exist at a depth of fifteen feet, and descend in some places to twenty, in others even to sixty feet. There, whether called Infusoria or no—whether animals, or according to the later views, plants—at a considerable distance from the surface of the earth, beyond the reach of heaven's light, without any direct

contact with heaven's air, they dwell, live, and multiply. Berlin's streets above are crowded with its *hundreds* of thousands of inhabitants; but beneath these same streets another living world, with its countless *millions* and *billions* of microscopic denizens, holds on its own way. Thus Berlin has its *ober* and its *unter* land; and the inhabitants of the *upper* are not independent of the inhabitants of the *lower country:* for it has been found that, in some quarters of Berlin, the stability of houses has actually been endangered by the subterranean operations of these minute tenants of the earth.

7. The discovery of Ehrenberg led immediately to similar ones in different and distant parts of the world. Pritchard tells us that there has recently been found moist earth near Newcastle, almost entirely composed of *living Infusoria* (Diatomaceæ ?) Masses of them, in a *fossil* state, exist in Richmond (Virginia), in Hanover, Sweden, Norway, &c. &c. Their shields, or silicious coverings, are still preserved, after the lapse of unnumbered ages, in most exquisite perfection and beauty. A powder from the *tripoli*, or *polishing slate*, of Franzen-

bad and Bilin in Bohemia, much used as an admirable polish for metals and jewels, is seen, under the Microscope, to consist chiefly of the silicious cases of Diatomaceæ. What an idea may we form of the immensity of life discovered by the Microscope, when we are told that the size of some of these silicious creatures is no greater than $\frac{1}{3456}$th of an inch! that in the *tripoli*, or *polishing slate* from Bilin, a *cubic line* contains, in round numbers, 23,000,000 (23 millions) of the Diatom called *Gaillonella distans;* and a *cubic inch*, 41,000,000,000 (41 thousand millions:)[1] that in a *single grain* of this polishing slate there are 187,000,000 (187 millions) of these individuals; or that the silicious coat of one of them weighs the 187,000,000th (187 millionth) part of a grain, as Sir David Brewster calculates;[2] or as Sir Charles Lyell puts it, that at every stroke we make with this polishing powder, perhaps tens of millions of perfect fossils are crushed to atoms![3]

[1] Owen's *Compar. Anat.* vol. i. p. 48.
[2] *Encycl. Brit.* Art. *Microscope*, vol. xiv. p. 805.
[3] Lyell's *Elementary Geology*, p. 25.

8. Our marvel at such discoveries must increase, when we reflect that the organization of many of these beings, whether animal or vegetable, is by no means simple or uniform. The animals possess stomachs and mouths, and around their bodies are hairs a million of times more minute than the most delicate hair in the human head! What a view does this give us of the works of the Creator! Into how infinitely minute a point may the Great Author of all existence compress the principle of life! No wonder, that here even the very infidel is constrained to adore the Almighty's power and wisdom! that even Hobbes exclaimed, "The majesty of God appears no less in small things than in great; and, as it exceedeth human sense in the immensity of the universe, so also doth it in the smallness of the parts thereof." The author of the *Vestiges of the Natural History of Creation* indeed tells us, that it were a most inconceivably paltry exercise of the power of God, to create certain of the lower creatures of the earth. The very tiniest of those creatures which the Microscope reveals, might silence such an interpreter of Creation's works, or rather

compel him to say, with Rousseau—" Si l'Auteur de la Nature est grand dans les grandes choses, il est très-grand dans les petites."

9. More profound still must be our admiration of the discoveries effected through the Microscope, when by its aid we discover that in His past operations, the Author of all has been pleased to employ these minute creatures, whether animal or vegetable, whether plants or shells,—in building up vast portions of His universe ! Thus one wide region of the south of France,—a great portion of the Jura,—the clay beds of London, —the wide-stretching chalk cliffs and downs of the south of England,—and innumerable mountain masses of limestone, spread up and down the island, are mainly made up of the remains of such organisms. Almost the whole sea bottom of the Levant is formed, and is still at this day increasing in thickness, from their remains. The accumulation of the deposits of infusoria is said to be now choking up some of the harbours in the Baltic Sea. And to conclude, the nummulitic limestone, forming a band often 1800 miles in breadth, frequently of enormous thickness, which stretches from the western shores of

Europe and Africa, to India and China, and also covers vast areas of North America, is found to consist chiefly of microscopic remains. How true the poet's words—

"The dust we tread upon was once alive!"

The towns of Richmond and Petersburg, U.S., it may be mentioned, are built of stones made up of myriads of the silicious skeletons of these organisms. The pavement of the quadrangle of the Royal Exchange of London is composed of Turkey stone. It may be here also noticed as an interesting fact, that the great Pyramid of Egypt is built of nummulitic limestone.[1] The operations of some of the lowest creatures in the universe of God, are thus placed in contrast with works which the mightiest of mankind have raised. And how great the contrast! For what are the Pharaohs of Egypt, and their countless hosts, and the toils endured by them through centuries, and the Pyramids which they thus reared, when compared with these invisible animalcules—these tiny servants of the Lord, which, during the untold ages of the past, were employed at Heaven's command, in fixing the

[1] Lyell's *Elementary Geology*, p. 231.

foundations of the earth, and in laying the floors of the ocean, and in building up the walls of the everlasting hills! And if the works of these minute labourers are so much more extensive, so, as Professor Owen remarks, "they will be infinitely more durable than the proudest mausolea by which Egyptian kings endeavoured to perpetuate the memory of their existence."[1]

As the earth receives much of its bulk from this source, so hence also it derives much of its fertility at the present hour. Vast masses of the richest mud that lines the banks of our rivers, and forms the beds of our seas, consist of infusoria, partly living, partly dead. The waters of the Nile, *e.g.*, are proverbially the wealth of Egypt. It was generally supposed that the degradation of rocks, and the decay of vegetable remains, rendered the waters of the Nile thus enriching. But the Microscope, in the hands of Ehrenberg, has brought to light the strange fact that this river owes its most fertilizing properties to the minute infusorial earths contained in its water. For it is found that when the flood of the Nile subsides, it leaves behind accumu-

[1] Owen's *Compar. Anat.* vol. i. pp. 40, 41.

lations of mud studded with masses of minute living forms. The extent of their numbers may be conceived, when we are told that a particle of the earth of the size of half a pin's head contains multitudes of the infusoria. Indeed, Ehrenberg states that particles of mud sent to him from many points of the globe, and not exceeding one-twelfth of an inch in thickness, often contained hundreds of distinct species!

"Oh, there are curious things of which men know
As yet but little! Secrets lying hid
Within all natural objects. Be they shells,
Which ocean flingeth from off her billows,
Or the low sand or flowers, or trees, or grasses,
Covering the earth; rich metals or bright ores
Beneath the surface. He who findeth out
Those secret things hath a fair right to gladness;
For he hath well performed, and doth awake
Another note of praise on Nature's harp
To hymn her Great Creator."

CHAPTER III.

MICROSCOPIC VEGETABLES.

1. THE Microscope has vastly extended the domains of the Botanist, and presents to his view new and amazing discoveries in the vegetable world. Two or three groups of minute plants, thus brought under the notice of the human eye, may specially engage our attention for a little: the *Desmidiæ*, or *Desmidiaceæ* (*so called from their division into symmetrical halves*); the *Diatomaceæ* (*i.e. easily cut through or broken*); and the *Volvocineæ* (a name derived from their *rolling motion*).

2. The *Desmidiæ* grow in fresh, the *Diatomaceæ* in fresh or salt water.[1] It seems now generally ruled that these organisms are vegetables, having, however, in their appearance and

[1] Carpenter on the *Microscope*, pp. 285, 320, 327.

habits, much resemblance to animals. These plants have the property of withdrawing *silex* from the water in which they exist, and thus their bodies, or at least their coverings, are indestructible. Here, again, we are called to admire the wondrous operations of the Framer of the universe, and to observe how by the most minute agencies He accomplishes his mightiest plans. If man would obtain one small dwelling to shelter himself from the icy cold, or to shade himself from the burning heat, what a mighty preparation of means! what an array of materials! what trenches and foundations! what scaffolding and heaps of rubbish! what a crowd of operatives of all classes! But by the small drops of heaven's dew, or rays of heaven's light —by the almost invisible particles of earth's frost, or the minute polypes of ocean's water, or by the countless agents of worlds of *Desmidiæ* and *Diatomaceæ*, the Great Master Builder rears and upholds the fabric of the material universe. Thus these Microscopic plants had their part in past ages in building up the walls of the world; and still day by day, unseen by the naked eye, unknown to the millions of earth, they are in-

creasing the soil of every land, and laying anew the foundations of every sea!

3. The Naturalists of the United States' recent exploring expedition brought up thousands of *Diatomaceæ* by every cast of the deep-sea sounding apparatus, alike in the Atlantic, Pacific, and Australian oceans. According to Dr. W. J. Hooker, these Microscopic vegetables abound throughout the South Polar Sea, between the parallels of 50° and 70° S. *Diatomaceæ* exist everywhere, stain the ice of a brown colour, or when put into water, render it cloudy like milk, and take hours to subside. A deposit of mud, 400 miles long, and 200 miles in breadth, stretches along the shores of the Victoria Barrier, and wherever soundings were here made, the average depth of the water being 1800 feet, they were invariably charged with *diatomaceous* remains—the immense deposit being thus proved to consist chiefly of these Microscopic organisms.[1] The Paris Basin, 180 miles long, and 90 miles in breadth, abounds in *infusoria* (so called) and other silicious remains.[2]

[1] Dr. Hooker's *Flora Antarctica*, vol. ii. pp. 503-505.
[2] Hogg on the *Microscope*, p. 156.

In all this there is a most wise and beneficent arrangement of Providence; for, as Dr. Hooker remarks, the universal prevalence of this invisible vegetation throughout the South Polar Ocean serves a great end. There is a marked deficiency, he tells us, of the higher forms of vegetation, and were it not for these *Diatomaceæ* there would be no food for the aquatic animals; nor, supposing these animals to exist by preying on each other, could the ocean waters, without the *Diatomaceæ*, be purified of the carbonic acid imparted to them by animals.

"How wondrous is the scene! where all is formed
With number, weight, and measure; all designed
For some great end! Where not alone the plant
Of stately growth, the herb of glorious hue,
Or food-full substance; nor the labouring steed,
The herb and flock that feed us; nor the mine
That yields us stores for elegance and arts;
The sea that loads our table, and conveys
The wanderer, man, from clime to clime, with all
Those rolling spheres, that from on high shed down
Their kindly influence; nor these alone
Which strike e'en eyes incurious, but each moss,
Each shell, each crawling insect holds a rank
Important in the scale of Him who framed
This scale of beings; holds a rank, which, *lost,*
Would break the chain, and leave a gap behind,
Which Nature's self would rue!"

4. We think much of the changes produced

on the material universe by the earthquake, the volcano, the hurricane—by rain, frost, and snow; we mark the additions made to it by the decay of its thousand forests, and the degradation of its lofty mountain-rocks, and the interment of its gigantic inhabitants, the elephant, the rhinoceros, the whale; but how striking is it to find that vastly more ancient, and still more extensive changes have been wrought by those minute creatures, which the Microscope has for the first time presented to the eye of man! And while such views should exalt our conceptions of the perfections of the Deity, how ought they to fill man's breast with humility and gratitude: with humility, as he thinks how his interests have been dependent on the agency of these least of all existences; and with gratitude, as he realizes how much, in the mysterious economy of nature, he owes to the silent, secret, but ceaselessly active, invisible agents, who, by land and water, are thus ever elaborating the atmosphere necessary for man's existence, or soil for his occupancy, or higher vegetables and animals for his food! Well may the author of that delightful little volume, "*The Sea-side Book*," say—"We

know not what we owe to these Invisible Plants."

" Sight could not trace their evanescent changes,
Nor comprehend their motions, till minute
And curious observation caught the clue
To this live labyrinth, where every one,
By instinct taught, performed its little task.
Millions of millions, thus from age to age,
With simplest skill, and toil unweariable,
No moment and no movement unimproved,
Laid line on line, on terrace terrace spread,
To swell the heightening, brightening, gradual mount.
Each wrought alone, yet all together wrought,
Unconscious, not unworthy, instruments
By which a Hand Invisible was rearing
A new creation in the secret deep.
Omnipotence wrought in them, with them, by them ;
Hence what Omnipotence alone could do,
Worms did.
Frail were their frames, ephemeral their lives,—
Their masonry imperishable."

5. The *Volvocineæ* are an extremely interesting class, both on account of the beauty and regularity of their forms, and their striking resemblance in their movements to real animals. They derive their name from the manner in which they *revolve* upon their own axis. Thus Leeuwenhoeck, who described some of the group at the distance of 150 years, speaks of an animalcule (then so regarded) " a thousand times

smaller than a louse's eye, which exceeded all the rest in briskness," and turned itself round as it were upon a point, with the celerity of a spinning-top.

The *Volvox Globator*, or "*Globe Animalcule*," is the most remarkable of the *Volvocineæ*. It is frequently found in fresh-water pools during spring and summer, and being $\frac{1}{30}$th of an inch in diameter may be seen by the naked eye, when the drop of water containing it is held up to the light. Viewed under the microscope, it is seen to consist of a hollow transparent sphere, which is studded at intervals with very small circular green spots. This circular creature was long supposed to be a *single animal;* but the Microscope, with its higher powers, now proves it to be a composite vegetable structure, existing in clusters, under a covering or mantle, and separated into cells to accommodate its many tenants. These cells often contain smaller cells, which are sometimes seen bursting through the side of the parent cell; and thus the process of multiplication is carried on.

The *Gonium*, or "*Tablet-Animalcule*," is also an interesting microscopic organism; especially

the *Gonium Pectorale*, or "*High Priest's Breastplate*," so called from its resemblance to the breastplate of the Jewish high-priest. It consists of sixteen bright green spherical bodies contained within a transparent mantle, like jewels reflecting light on both sides; or, as Mr. Gosse observes, "like emeralds set in a plate of the purest glass."[1] These "emeralds" are disposed in quadrangular form, like the precious stones in the high-priest's breastplate, the four centre ones being generally larger than the others, and each "emerald" is joined to its neighbour by six links or cords. How many and beautiful are the archetypes of the Lord, both in Creation and Redemption!

6. Ere we leave the vegetables, we would glance at one group among the *Volvocineæ*—at the *Monas Crepusculum*, or "*Twilight Monad.*" It is the most minute and simple of all living beings which the Microscope, in the exercise of its highest powers, has yet discovered. This monad is $\frac{1}{12000}$th of an inch in size! Twelve thousand of these plants would be easily disposed of within the length of an inch, if they

[1] *Life*, p. 21.

were placed, like the beads of a necklace, side by side in contact with each other. One drop of water would contain a thousand millions of them, though each was separated from its neighbour by a space as large as its own diameter. Thus, that globule of water would contain as many *Monads* as the great globe has of human beings on its wide surface in our own day!

It is still contended that the Monad must be classed with *animals*. If so regarded, the "Twilight Monad" may supply a standard for comparing the size of different objects. If the *Rorqual* (whale), the largest animal, is one hundred feet in length, and the *Monad* $\frac{1}{12000}$th of an inch, then the *common house-fly* may be considered as occupying the middle place in creation.[1] But in that least, as certainly as in that largest, of organized material creatures, we have full proof of the presence and perfections of the Creator. "Are we struck with admiration," Coleridge asks, in one of his pregnant sentences, "at beholding the cope of heaven imaged in a dew-drop? The least of the ani-

[1] Gosse's *Life*, p. 10.

malcules, to which that drop would be an ocean, contains in itself an infinite problem, of which God omnipresent is the only solution."[1]

"I tell thee that those living things
To whom the fragile blade of grass
That springeth in the morn
And perisheth ere noon,
Is an unbounded world—
I tell thee that those viewless beings,
Whose mansion is the smallest particle
Of the impassive atmosphere,
Enjoy and live like man;
And the minutest throb
That through their frame diffuses
The slightest, faintest motion,
Is fixed and indispensable
As the majestic laws
That rule yon rolling orbs."

[1] Coleridge's *Lay Sermons.*

CHAPTER IV.

MICROSCOPIC ANIMALCULES.

1. We would now introduce to our general readers a few of the *Infusoria*,—these marvellously minute works of the Lord of the Universe, " whose glory is no less displayed in the construction of an Animalcule than in the creation of a Solar System."

2. The *Polygastrica*, or " *Many-stomached*," as a very extraordinary race of beings, may well occupy our attention for a little. Ehrenberg observed in the bell or funnel-shaped body of this animalcule, numerous pellucid little globes or beads, and concluding these to be *stomachs*, applied to it the designation, " Many-stomached." Later naturalists seem to agree in denying that these globules are to be regarded as stomachs, but the original appellation is continued. The class comprises very minute forms

of life. A drop of water, it is said, may contain 500 millions of a certain kind. They are of various colours. They multiply themselves by buds, or by spontaneous division—sometimes in the length, and sometimes in the breadth. Sometimes one parent is seen to contain many offspring, and the offspring often passes into a separate state of existence through the shell, or covering of its parent!

3. To one singular feature in the history of the *Polygastrica* we must still more particularly refer. They have apparently no articulated limbs, yet by means of *cilia* (eye-lashes or filaments, resembling very small hairs), some of which are only $\frac{1}{13000}$th of an inch in length, they can move with a velocity which the eye can scarcely follow; ay, perform feats which the most famous performer at Astley's might well admire, but would hardly venture to imitate; walking, running, jumping, wrestling, flying, swimming, creeping; so that there is no kind of animal movement which they do not occasionally exhibit. Their *gymnastics* are truly extraordinary! One part of the frame, of some of them at least, the cilia, has attained what

man's head and hand have long in vain sought to discover—the *perpetual motion.* For these strange *filaments*, like our globe itself, never cease to revolve: whether it be day or night, light or darkness, the *cilia* exhibit the same circling movements, which seem to cease only with life. *Do these movements indicate consciousness?* The question has perhaps not yet been fully answered. Dr. Carpenter, though favouring the negative, speaks doubtfully.[1] Professor Owen's remarks on the subject are especially worthy of consideration: "If you watch the motions of the Polygastric infusoria, you will perceive that they avoid obstacles to their progress; rarely jostle one another; yet it is difficult to detect any definite cause or object of their movements. The motions of the Polygastrica have appeared to me, *long watching them for indications of volition*, to be in general of the nature of respiratory acts, rather than attempts to obtain food, or avoid danger. Very seldom can they be construed as voluntary, but seem rather to be automatic, governed by the influence of *stimuli* within or without the body, not felt but reflect-

[1] Carpenter on the *Microscope*, pp. 476, 478.

ed upon the contractile fibres, and therefore are motions which never tire. We may thus explain the fact which Ehrenberg relates—not without an expression of surprise—namely, that at whatever period of the night he examined the living *Infusoria*, he invariably found them moving as actively as in the day-time; in short, it seems to him that these little beings never sleep."[1]

This life of ceaseless activity is indeed not long: but the watchful devotee of science has traced an infusoria through a course of existence, extending to *an old age of twenty-three days!*

4. To a true Animalcule, of high and complex organization, brought to view by the Microscope, we must still request our reader's attention; namely, the *Rotifer*, or "*Wheel Animalcule.*" These animalcules belong to the *articulated* division of the animal kingdom, and seem to constitute a class in that lower portion of it, to which the designation *worm*

[1] *Lectures on the Compar. Anatomy and Physiology of the Invertebrate Animals*, p. 19. 1843.

is given.[1] The name Rotifera, or "Wheel Animalcules," was assigned to them from their having, in the anterior part of their body, little organs like wheels; and which, like wheels, continually move upon their own axis. *This appearance is as extraordinary, as if the head of a man were seen to be continually whirling round on the axis of his neck.*

Though the Rotifer is not the $\frac{1}{36}$th of an inch long, it possesses tail and eyes, chin and mouth, jaws, teeth, and stomach. Mr. Gosse states that the muscular, the nervous, the digestive, and the reproductive systems of the "Wheel-bearers," are particularly well developed.[2] By their cilia, these *Infusoria* create a *lilliputian* whirlpool in the water, and by the movement suck their prey into their mouth. They produce their progeny by eggs, from which the young often pass while yet in the body of the parent! And so rapid is the process, that, according to Ehrenberg, seventeen millions may be produced within twenty-four days from one individual! They are evidently

[1] Carpenter on the *Microscope*, p. 473.
[2] *Life*, p. 198.

a decidedly anti-Malthusian race! As the Rotifer is remarkably transparent, all these facts are easily observed with a good Microscope.

5. In this class, the *Melicerta Ringens*, or "*Beaded Melicerta*," claims special notice. It is called "Beaded" from the cylindrical tube, or house which it inhabits, being made up of little round pellets glued together, which give the tube a granulated or beaded character. The *Melicerta* builds its own house, and also makes the stones that are laid in its walls. It exudes, from a *cup-like* organ in its own body, a viscous matter for forming little beads or pellets, and with these it raises, course after course, and storey after storey, its tubular abode. Mr. Gosse tells us that he enjoyed the privilege of witnessing the operations of the little mason, as it was rearing its tasteful mansion, after an order still more ancient than the Doric. He observed beneath the *Melicerta's* chin a small disk-like organ, having the appearance of a revolving ventilator ("like that fixed in the upper pane of a kitchen-window for curing smoke"), when the wheels are at work. Towards this disk, through the action of the cilia, particles of

matter are drawn from the surrounding liquid into the vortex of the wheel organs, and so accumulate there, until the pellet—the stone for the wall—is framed of the necessary materials. It requires about three minutes to prepare the pellet. Then the little architect, having popped up its head out of its tube ("like a sweep peeping out of a chimney-top"), bends down its body, seizes the pellet, and lays the stone in its bed—in other words, attaches the newly formed pellet to its own niche on the edge of the gradually rising tubular structure. The head is then lifted up, and the same process of collecting materials and bringing them to the stone-manufactory, of making the pellets, and of raising the walls, commences anew.[1] This Architect-Mason animalcule is about two-thirds of a line in length;[2] and when young has two eyes, teeth, and gizzard. Its teeth are like toothed hammers, fixed on the movable end of the jaw, to strike, or pound as on an anvil. Respiratory tubes are sometimes seen. Ehrenberg maintains that this creature has brains!

[1] *Transactions of the Microscopical Society*, ii. 3, 4, 5.
[2] A *line* is one-twelfth of an inch.

6. If the contemplation of one animalcule presents so marvellous a spectacle, what shall we say when we behold them in multitudes which no man can number? Well has it been observed:—"To see a shoal of these lively creatures in a drop of water, avoiding each other in their many courses, and performing a thousand mingled evolutions, is, perhaps, one of the most interesting spectacles which the reflective can contemplate! But this delight gives way to astonishment when we perceive that these creatures are elaborately constructed; that they are organized with an express relationship to their destined mode of life; and that they enjoy their existence like the fishes of the sea, the birds of the air, or the wild beasts of the desert."

Contemplating such a scene, we may well adopt the words of the poet:—

"See thro' this air, this ocean, and this earth,
All matter quick, and bursting into birth.
Above, how high progressive life may go!
Around, how wide! How deep extend below!
Vast chain of being! which from God began;
Nature ethereal, human, angel, man;
Beast, bird, fish, insect, what no eye can see,

No glass can reach; from Infinite to Thee,
From Thee to nothing!"

"How wonderful are thy works, O Lord; *sought out* of all them that have pleasure therein."

7. The marvel of marvels regarding the Rotifera still remains to be told; *their tenacity of life.* They may be taken out of water, kept dry as dust, and retained in this condition for almost any length of time; yet, when exposed to the influence of moisture and heat, they may be restored again to all their former animation! Fontana, an Italian naturalist, kept some Rotifera in dried sand for two years and a half; but, after an application of rain-water for two hours, most of them appeared to return to life and motion.[1] Spallanzani, after keeping the creatures for four years in a torpid state, repeated these experiments with the same success. He further tried the power of revival after apparent death, by alternately drying and moistening the same individuals. At each trial some failed to recover; some recovered many times; one of them actually revived fifteen times, but died on the sixteenth trial.[2] Individuals of one

[1] Paterson's *Zoology*, p. 8.
[2] Owen's *Comp. Anat.*, vol. i. p. 39.

tribe have been kept in a vacuum for thirty days; they have been subjected to the most trying species of desiccation known, by the use of sulphuric acid and chloride of calcium, and yet they have revived again.[1] Professor Owen says, that he witnessed at Freiburg, in 1838, the revival of an Arctiscon which had been preserved by Professor Schultze in dry sand upwards of four years.[2] Some have hence ventured to conclude that there is here a true and complete revivification—a restoration of life! The highest authorities, Ehrenberg and Humboldt, justly maintain that in such cases there had been *no death;* that the principle of life, though enfeebled and dormant, had never actually fled.[3] But even with this explanation, how startling the phenomenon, that an invisible animalcule, with an amazingly minute and delicate organization of head, eyes, mouth, jaws, teeth, throat, stomach, should be dried up to dust, remain dormant, as if dead, for years, and yet revive again! How strange such a sleep! How

[1] Carpenter on the *Microscope*, p. 497.
[2] Owen's *Comp. Anat.*, vol. i. p. 40.
[3] Humboldt's *Aspects of Nature*, p. 240.

strange such a waking! Such an entombment and such a resurrection! Yet the evidence is undoubted. Well, then, may we ask with the poet—

> "And deems weak man the *future promise* vain,
> When worms can die, and glorious rise again?"

Well may we ask with Paul, and in words supplied by Him who is Himself the Resurrection and the Life, "Why should it be thought a thing incredible (with you) that God should raise the dead?"

> "Can it be?
> Matter immortal? And shall spirit die?
> Above the nobler, shall less noble rise?
> Shall man alone, for whom all else revives,
> No resurrection know?
> . . . .
> Here dormant matter waits a call to life;
> Half-life, half-death, join there; here, life and sense;
> There, sense from reason steals a glimm'ring ray;
> Reason shines out in man. But how preserved
> The chain unbroken, upward to the realms
> Of incorporeal life? Those realms of bliss
> Where death hath no dominion?"
> . . . .
> "The time draws on
> When not a single spot of burial earth,
> Whether on land, or in the spacious sea,
> But must give back its long-committed dust
> Inviolate:—And faithfully shall these

Make up the full account; not the least atom
Embezzl'd, or mislaid, of the whole tale.
Each soul shall have a body ready furnish'd;
And each shall have his own.—Hence, ye profane!
Ask not how this can be?—Sure the same power
That rear'd the piece at first, and took it down,
Can re-assemble the loose scatter'd parts
And put them as they were. Almighty God
Has done much more: nor is His arm impair'd
Thro' length of days: And what He can, He will:
His faithfulness stands bound to see it done."

8. The discovery of the existence and agency of these microscopic plants and animacules unfolds to us clearly the power, wisdom, and goodness of the Almighty, as put forth in all nature around us. Before the invention of the Microscope, not a conception could be formed by man of the vast world of animated nature in every drop of water. But it is now known that if a few leaves or grasses are immersed in this element, and then left exposed to the sun for a little time, innumerable multitudes of microscopic forms,—many of them evidently possessed of the most amazing powers of locomotion, are brought to light. We see this realized every day in every little stagnant pool which we pass by on the road-side. On the surface of that pool you observe a mass of apparently putrid

matter; but by and by, vegetable and animal life appears, and the putrifying process ceases. The water becomes pure and fit for use, and so continues as long as the vegetation is healthy. Professor Quekett tells us, in his interesting Lectures on Histology (published in 1852-4), that there was before him, on his lecture-table, a vessel with water, which had thus been kept pure for four years, and which, he stated, would still continue for any length of time in the same condition, so long as that water was tenanted with living plants and animalcules.[1] Shall we, then, any longer despise that little roadside pool, or count these microscopic plants and animals useless? We are apt to be astonished, ay, disgusted, when we hear of these objects existing in water. But mark the beneficence of God. The plants require carbonic acid as their food, and the animalcules require oxygen to keep them alive. The plants obtain carbonic acid from the decomposition of animal matter, and again give out oxygen for animalcules. The animalcule receives this oxygen, and, in return, by breathing, liberates carbonic acid gas, to be

[1] *Lectures on Histology*, vol. ii. p. 99.

again decomposed by the plants. The fact of oxygen gas being so produced was carefully tested by Liebig. In order to satisfy himself of its accuracy, he placed several kinds of Infusoria (Protophytes) in a jar of water, and found, as the result, that oxygen gas was rapidly manufactured, and accumulated in the upper part of the jar. At the end of fourteen days, one-third of the water had been forced out, and the gas, which had taken its place, was capable of igniting a glowing mass of wood. Thus these microscopic plants and animalcules perform the office of scavengers to the important element of water, removing all dead and putrifying organic matter, and rendering the water bright and inodorous. And so exquisite is the balance between animals and plants, that the streams of a thousand rivers, and the waters of the great ocean itself, are thus kept in clearness and purity throughout their wide extent. Professor Owen has well and happily styled these minute creatures "Nature's invisible police."[1]

[1] Owen's *Compar. Anat.* vol. i. p. 27.

CHAPTER V.

MICROSCOPIC ILLUSTRATIONS.

1. THE marvels of the invisible world, as thus illustrated by the Microscope, may explain many perplexing passages that we meet with in the records of history, and in the events of every-day life.

2. In his *Aspects of Nature*, Humboldt states that the Otomacs, a tribe inhabiting the banks of the Orinoco, subsist by *eating earth* during a part of the year when they have no other food. They knead this earth into balls, bake them, and use them as their only sustenance during two or three months of the year. "If an Otomac be asked," says Humboldt, "what are his winter (the rainy season) provisions, he will point to the heaps of clay in his hut."[1] Nay, this race so much relish their earthen

[1] *Aspects of Nature*, pp. 142-4.

balls, that, while other food abounds, they eat them *by way of dessert*, or as a *bonne bouche*. Similar reports have prevailed as to men eating earth in Finland, Guinea, Java, and other places; and the propensity of slaves in the West Indies to follow this practice, even to the injury or destruction of their health, is well known.[1] The Microscope explains the mystery, at least in some of these cases, and so confirms the statements. This earth, examined by our instrument, is found to consist of *infusorial matter*, *i.e.*, is mainly made up of minute organized beings, either animal or vegetable. It is found in many places,—in Algeria, Bermuda, Richmond in Virginia, Dolgelly in North Wales, Mull in Scotland, Lough Mourne in Ireland, &c. The Swedes and Norwegians have deposits of this infusorial earth, and call it by the very appropriate name of *Berg-mehl*, or *mountain meal*. In times of dearth, in China, such earth has been used for food, and is called *fossil flour*.

3. Who has not heard, and, hearing, who has not smiled at apparently incredible stories of red

[1] *Aspects of Nature*, pp. 145-6. Chambers's *Paper on the Microscope*, p. 13.

snow and green snow, red rain and black rain? We thought, perhaps, that we were fully warranted to give up to the scoffer, Livy's old stories of showers of blood descending in the Forum and Capitol, and of earth being rained down upon the streets in Rome (*Livy*, xxxiv. 45); but the tidings of rain and snow—red, black, and green—came from so many quarters, and were vouched for by so many respectable authorities, that our early scepticism began to sit somewhat uncomfortably upon us. At length the Microscope has rendered a large portion of it perfectly untenable. Illustrations are here very numerous.

Thus on January 31, 1687, a great mass of a black substance, said to be like paper, fell during a storm in Courland. The wise said it was meteoric matter, but most men wondered, and pronounced the event a mystery. Fortunately, a portion of the "black mass" was laid up in the Berlin Museum, to puzzle the learned for one hundred and fifty years. But more fortunately still, at the end of that long *dark age*, Ehrenberg one day applied his Microscope to the marvel, and found it to be a matted heap of minute

organisms,—a few *Confervæ*, and about *thirty kinds* of *infusoria*. Thus a glance with the Microscope solved a riddle which had perplexed Europe's philosophers for more than a century.

Murray tells us, in his *Handbook for Switzerland*, that *red snow* is common among the high Alps. *Rose-coloured snow* fell to the depth of six feet in the Tyrol in 1808. *Green snow* has been collected in Spitzbergen. Sir John Ross collected *red snow* upon a range of Arctic hills 800 feet above the level of the sea. *Black rain* fell in Ireland in April 1849, over a surface of 700 square miles. Humboldt observed *red hail* near Bogota.

4. Again the Microscope unties the knot. It has been found that in such cases a minute red, sometimes green, coloured plant, called the *Protococcus*, penetrated and pervaded the snow, and so imparted the colouring. In other cases, vast numbers of microscopic animals, floating in the air, had descended with rain or snow, and so produced the phenomena.

5. In a work entitled *Passat-Staub und Blut-Regen*, Ehrenberg has investigated this whole subject very carefully, and records the occur-

rence of no fewer than 340 showers of blood-rain and dust-rain. In this treatise he advances the remarkable position, "*that there must exist some law of nature according to which these living organisms may develop themselves in the air.*" He also calls special attention to extraordinary cases, viz., the dust-shower at Lyons in 1846, where an immense mass of matter must have fallen, weighing 7200 cwt.; the occurrence of *red mist*, and then a descent of blood-rain at Locarno, near Lago Maggiore in 1755, leaving a red deposit, which must have covered forty German miles square; and a shower of dust which fell upon the deck of a vessel in the Atlantic ocean, about 500 miles from the west coast of Africa. In this last case, the animalcules, fifteen species in all, which fell with the dust, when collected and examined by Darwin, proved that the wind must have floated the mass from the shores of South America.[1] This fact goes to support a remarkable theory stated by Humboldt in his *Aspects*, namely, that "*many of these agglomerations of silicious-shelled microscopic organ-*

[1] It is to be remembered, that not a few of the Infusoria are to be found only in certain geographical areas.

isms may perhaps float for years in the highest strata of the atmosphere."—P. 211. (See below, Chap. viii. Sect. 11.)

6. These facts cast light on a mysterious page in D'Aubigné's *History of the Reformation.* The scene to which we refer, is depicted with all the historian's graphic felicity in vol. iv. book xvi. ch. v., where he treats of Zwingle and the Reformation in Switzerland. It is amusing to observe that while D'Aubigné makes a kind of apology for introducing the story, he carefully refrains from committing himself either to its truth or falsehood.

" On the 26th July (the year was 1531), a widow, chancing to be alone before her house in Castelenschloss, suddenly beholds a frightful spectacle—blood springing from the earth all around her. She rushes in alarm into the cottage, but oh, horrible! blood is flowing everywhere—from the wainscot and from the stones; —it falls in a stream from a basin on a shelf, and even the child's cradle overflows with it. The woman imagines that the invisible hand of an assassin has been at work, and rushes in distraction out of doors, crying ' Murder, mur-

der!' The villagers and the monks of a neighbouring convent assemble at the noise—they succeed in partly effacing the stains; but a little later in the day, the other inhabitants of the house, sitting down in terror to eat their meal under the projecting eaves, suddenly discover blood bubbling up in a pond,—blood flowing from the loft,—blood covering all the walls of the house, —*blood, blood, everywhere blood!* The bailiff of Schenkenberg, and the pastor of Dalheim arrive, inquire into the matter, and immediately report it to the lords of Berne and to Zwingle."

By the help of the Microscope, we may safely conclude that the bloody omen, which three hundred years ago caused such consternation in the canton of Berne, and which doubtless immediately formed the topic of solemn deliberation in the council-chamber of the Lords of Berne, and in the circle of the Hero of the Swiss Reformation, was nothing more than an extraordinary descent of microscopic coloured plants or vegetables, which, as we have seen from Murray's *Handbook*, is often witnessed at this day in the higher regions of the Alps. Thus science, truly

applied, solves many a strange phenomenon—explains many a fairy tale—and destroys many a superstitious prejudice; while it opens to us a fresh page in the book of nature, and constrains us anew to say, "Great and marvellous are thy works, Lord God Almighty!"

7. These brief, and necessarily imperfect illustrations, must convince us that boundless and glorious as is that universe afar off, whose realms the Telescope has surveyed, and whose remotest depths it still vainly attempts to fathom, there is another universe at hand, which the Microscope brings under our ken, and whose beauties and glories it still more fully subjects to our gaze! Yea, as we reflect how the Microscope conducts man into the hitherto inaccessible and most mysterious regions of this minute universe,—lights up the darkest abodes of recently unseen and unsuspected existence,—presents forms of surpassing beauty and matchless delicacy to our view, and reveals to us new races of beings, new modes of production and new laws of organization, new powers of vital action and new functions in exercise; we may almost venture to ask if this little Instrument, with its

scarcely visible lenses, has not, in the hands of an Ehrenberg, or an Owen, achieved discoveries even more unexpected and marvellous, than when Herschel, with his Telescope, saw the broad milky way that belts the heavens as a vast girdle of blazing stars, lying like glittering dust along heaven's dark sky; or when Lord Rosse, traversing the firmament with his gigantic instrument, in a moment resolved the great Nebula in Orion into a cluster of glowing stars, or surveyed the planet Neptune in its far distant home? Yet after all that those instruments have revealed to us—after we have with the one penetrated to that remote heaven, and seen its stars in their brightness and grandeur; or with the other pierced into the minutest fragments of matter, and surveyed the delicacy and beauty of its organized atoms, we are but the more impressively taught this lesson—at once the highest and the most humbling—that beyond the far distant Neptune which the Telescope has brought to our view, and beyond the little Monad which the Microscope has looked upon, there are worlds upon worlds above that planet, and beneath that animalcule; and that the unknown infinities on

their farther sides may yet more fully display the wisdom, and power, and goodness, of their Author, than do all the known infinities that lie between them. For the infinite is everywhere, and in all things—the infinitely great and the infinitely small. In the material as well as in the spiritual world, "eye hath not seen, nor ear heard, neither have entered into the heart of man the things of God!" What need then, even here, of the wisdom that cometh from above! and of the teaching of that Spirit who searcheth all things, even the deep things of God! And in a better world what boundless fields of ennobling contemplation may await the student of nature—instructed also in the still more precious volume of inspired truth—when, with a mind taught by the Omniscient, and a heart purified by the thrice Holy One, he enters upon the vision of the new Heaven and new Earth, amid the unclouded and full-orbed light of that land, of which Immanuel is at once the Sun and the Glory!

"What numerous tribes—
Evading even the Microscopic eye!

Full nature swarms with life; one wondrous mass
Of animals, or atoms organized.
. . . . .
And lives the man, whose universal eye
Has swept the unbounded scheme of things,
Mark'd their dependence so, and firm accord,
As with unfaltering accent to conclude
That *this* availeth nought? Has any seen
The mighty chain of beings, lessening down
From *Infinite Perfection* to the brink
Of dreary *nothing*, desolate abyss!
From which astonish'd thought, recoiling, turns?
Till then, alone let zealous praise ascend,
And hymns of holy wonder to that *Power*
Whose wisdom shines as lovely on our minds,
As on our smiling eyes his servant Sun."

CHAPTER VI.

THEORIES AS TO THE ORIGIN OF LIFE.

1. Did space permit us fully to examine the wide field of observation and discovery over which the Microscope conducts us, we should find that while this tiny instrument may gratify curiosity to the uttermost, it will also aid us in the practical duties of every-day life—subserve our best interests, even in matters affecting our prosperity, our health, our honour, our good name, ay, our very life—and help us to solve great questions connected with the glory of God and man's destinies for eternity. Thus the theologian and the philosopher, the naturalist and the antiquarian, the merchant and the manufacturer, the agriculturist and the chemist, the anatomist and the physician, the lawyer and the judge,—may, in the most ordinary details of business, or in the highest departments

of their profession, oft summon this instrument to their help, and with rarest success.

2. In reference to that great, and in our day vexed, question, *whence, and what is the origin of living beings?* the Microscope aids us at least to detect and expose the fallacies of men whose solution of this question seems as unphilosophical as it is evidently antiscriptural. The Microscope gives no countenance either to a *generatio spontanea*, or a *transmutatio speciei*. Notwithstanding the famous experiments of Mr. Crosse and Mr. Weekes, and their "*Creation*" of the "*Acarus*"—or certain hypotheses regarding the *Entozoa*,—or recent speculations regarding the primitive production of Infusoria, —or doctrines about "Creation by Organic Law,"—our instrument authorizes us still to maintain, that organic life can arise only from organic life; that the very lowest of plants and animalcules are never produced from inorganic matter by any fortuitous combination of circumstances; that while there may seem to be different stages of development in the same being, or in its descendants for one or two generations, there is never a final passing

away from the original type; and that while all organized beings may be traced up to elementary cells, *the cell of every plant and animal is peculiar to itself, and never develops itself into that of another.*

3. The "Law of the Alternation of Generations," as it has been termed, may present us with facts which, at first sight, appear startling, and inconsistent with the generally received laws of organic life. But these phenomena, when followed out and fully considered, instead of shutting out the thought of the Creator and Preserver of all living things, only give us new views of that Being whose works are as manifold as they are great. One fact connected with the "Alternation of Generations" seems undoubted; namely, *that whatever be the degree or duration of the alternation, the original type of existence eventually re-appears.* We at once admit that the changes under this law are not to be explained satisfactorily, by comparing them with the metamorphoses of certain insects and crustaceans. In the latter cases, as Mr. Gosse observes, one individual passes through a succession of forms by casting off a

succession of garments that concealed, and as it were masked the final form. Thus the caterpillar actually contained the butterfly. The new form was within the old. But in the alternation of generations, we have the appearance of repeated births or descents, where the progeny is different from the parent, and possibly quite dissimilar. But sooner or later there is a return to the likeness of the early branch of the family. The pages of Professor Carpenter supply us with abundance of illustration and argument on this point. In the *Vorticella*, for example, what a dissimilarity between parent and progeny! The *Vorticella* passes into the form of an *Acineta;* and this acquires a new stalk, which exhibits the appearance of a *Podophrya*.[1] And so great is this difference between the Vorticella and the Acineta, that Ehrenberg himself regarded them as of a different *genus*.[2] Similar metamorphoses are presented by another animalcule, as it passes through the various changes in which it is styled the *Trychoda lynceus*, *Aspidisca*, and *Oxytricha*.[3] The *Pro-*

[1] Carpenter on the *Microscope*, pp. 481, 482.
[2] Gosse's *Life*, p. 15.
[3] Carpenter, pp. 483, 484.

teus Amœba receives its very name from the great variety of forms which it assumes.[1] It is always changing its outline, and to such a degree, that not only are no two ever found alike, but the same specimen does not retain the same shape for two successive minutes.[2] And so we have the most extraordinary alternations of forms in the same animalcule, *Hydra*, *Strobila*, *Medusa*, where the parent for the time does not produce its own likeness, but something wholly diverse,—"each individual being altogether unlike its mother, or its daughter, but exactly resembling its grandmother or its granddaughter."

The school of naturalists who draw conclusions in favour of *their law of development*, from the circumstance of a microscopical animalcule passing into another form, or apparently giving origin to a totally different creature, should carefully ponder the following words of a keen-eyed microscopic observer:—"There is a very strong analogical probability, that *many even of the most dissimilar* forms of these animalcules will prove to be *different*

[1] Carpenter, p. 464. [2] Gosse's *Life*, p. 22.

states of one and the same; for their multiplication, by binary subdivision, being *not a true generative* process, but merely (so to speak) the growth of an individual, we may be almost certain that sooner or later a new phase will present itself, consisting in the evolution of proper sexual bodies, which will perform a true generative act, the products of which may be very probably quite different from the forms we are accustomed to regard as peculiar to each species."[1]

4. It is pleasing to find that the highest authorities among naturalists (without a discordant voice) oppose the conclusions in favour of the hypotheses of a *generatio spontanea*, or a *transmutatio speciei*, which some have recently attempted to draw from such phases of life and reproduction as the preceding.

5. "The hypothesis of equivocal generation," says Professor Owen, "has been deemed to apply more strongly to the appearance of *internal parasites* (*Entozoa*) in animal bodies, than to the origin of animalcules in infusions. But if a

[1] Carpenter on the *Microscope*, pp. 18, 20.

tapeworm might be organized from a fortuitous concourse of organic particles, or by the metamorphosis of an organic cell in the animal it infests, why that immense complication and extent of the organs for the production of normal fertile ova ?"[1]

6. " The universality," says Professor Carpenter, " of simple forms of fungi upon all spots favourable to their development, has given rise to the belief that they are spontaneously produced by decaying vegetables ; but there is no occasion for this mode of accounting for it, since the extraordinary means adopted by Nature for the production and diffusion of the genus of these plants adequately suffices to explain the facts of the case."—" A single individual of the puff-ball tribe has been computed to send forth no fewer than ten millions of sporules. Their minuteness is such, that it is difficult to conceive of a place from which they should be excluded. This mode of explanation has received further confirmation from the facts recently ascertained in regard to the *great num-*

[1] Owen's *Comp. Anat.* vol. i. p. 54. The ova in one individual of the Entozoa amount to sixty-four millions.

ber of forms under which a *single germ* may develop itself."[1]

Professor Carpenter elsewhere pursues a similar course of argument in reference to the *Infusoria*:—"When we consider the extraordinary rapidity of the multiplication of these animalcules, and the fact that a succession of different forms may be presented by one and the same being, the difficulty of accounting for the universality of their diffusion, which has led some naturalists to believe in their 'spontaneous generation,' and others to regard them as isolated particles of higher organisms set free in their decomposition, so as to constitute an 'equivocal generation,' is as easily got over as we have seen it to be in the case of the fungi."[2]

7. At one period the *Yeast-plant* was adduced as a striking example of the *spontaneous production of cellular substances.* A few lines from the pen of the late Professor James F. W. Johnston scatter such fancies to the winds:—"The yeast with which we raise our bread is a minute plant belonging to the division of the *Confervæ*.

[1] Carpenter on the *Microscope*, p. 383.
[2] *Ibid.* p. 485.

If we make a thick syrup of cane-sugar, and strew a few particles of this yeast upon it, they will begin to grow and propagate, will cause minute bubbles of gas to rise, and the whole syrup gradually to ferment. . . . In the juice of ripe grapes, it has a more favourable medium still. If we filter this juice, we obtain a clear, transparent liquid. Within half an hour this liquid begins to grow first cloudy, and afterwards thick, to give up bubbles of gas, or to ferment, and in three hours a greyish yellow layer of yeast has been already collected on its surface. In the heat of the fermentation the plants are produced *by millions*—a single *cubic inch* of such yeast, free from adhering water, containing *eleven hundred and fifty-two millions* of the minute organisms. . . . The cells, or globules, vary in size from $\frac{1}{7500}$ to $\frac{1}{2500}$ of an inch. . . . Whence come the seeds of this yeast-plant, which propagates itself with such wonderful rapidity? Do they exist already in the juice of the living grape? Do they cling to the exterior of the fruit, or do they float perpetually in the air, ready to germinate and multiply wherever they obtain a favourable oppor-

tunity? Whichever way they come, it would be *too slow a process to wait for the natural appearance* of these plants in the worts of the brewer and distiller."[1] The juice of the grape propagates the seeds of the yeast with this wonderful rapidity, "because it contains the food which, in kind, in form, and in quantity, is best suited to its rapid growth. . . . The minuteness of the yeast-plant, consisting in its simplest form of only a single cell, long prevented it from being generally regarded as a *form of living matter. But the changes it undergoes in the fermenting tub, day by day, as shown by the Microscope, prove it to be unquestionably a growing vegetable.*"[2]

8. In his *Bridgewater Treatise*, Dr. Prout thus disposes of the theories we have been considering:—"All hypotheses assumed to explain organization by *laws*, whether by *laws of matter*, or by what are called *laws of development*, must be rejected. . . . We are drawn irresistibly to the conclusion, that when a new and specific organized being is required, *a new and specific*

[1] *Chemistry of Common Life*, vol. i. pp. 84, 85.
[2] *Ibid.*, vol. i. pp. 298, 299.

act, equivalent to an act of creation, must be performed."[1]

9. In his work in the same series, Dr. Roget, who was strangely represented by the author of the *Vestiges* to be in favour of his own peculiar views, as thoroughly condemns the "development theory." "Whatever may be the apparent similarity between one animal and another, during different periods of their respective developments, there still exist specific differences, establishing between them an impassable barrier of separation, and effectually preventing any conversion of one species into another, however nearly the two may be mutually allied. The essential characters of each species, amidst occasional varieties, remain ever constant and immutable." And alluding to Lamarck's proposition, that there was originally no distinction of species, but that each higher race had originally sprung from a lower, "*and that infusorial animalcules, spontaneously formed out of original molecules, gave birth, by successive transformations, to all other animals now existing on the globe,*" Dr. Roget justly con-

[1] Prout's *Bridgewater Treatise*, pp. 409, 410.

cludes, "*If this be philosophy, it is such as might have emanated from the college of Laputa.*"[1]

10. Professor Whewell maintains similar views with equal earnestness, quoting the opinions of the most eminent naturalists (Cuvier being specially named), as giving an "indisputable preponderance to that decision which rejects the transmutation of species," and which accepts the principle "that the changes of which each species is susceptible, though difficult to define in words, are limited in fact."[2]

11. In Professor Sedgwick's invaluable *Discourse*, we have a note on the "Alternate Generations of Steenstrup," "Parthenogenesis of Owen," &c., well worthy of the careful study of those who would investigate these interesting questions. We select a few quotations:—

"In some of the lower families of the animal kingdom *larvæ* are incredibly fruitful, and for several successive generations (sometimes amounting to eight or ten) have an inherent power, without any new sexual union, of maturing and bringing forth new forms of larval life, till the specific organic cycle is complete;

[1] Roget's *Bridgewater Treatise*, vol. ii. pp. 636, 638.
[2] Whewell's *Indications of the Creator*, pp. 97-101.

and then the two sexes are perfected, either in the same or in different individuals (as the case may be), by the union of which the same cycle may begin again, with similar successive changes of larval development. *But in cases such as these, there is no specific change in the perfect animals.* They are of the same species with the parents from which they originally sprang, and though they may originate once again a most complicated series of organic changes, yet all such changes are governed by stern laws, whereby they are resolved into cycles, and in the end produce but another repetition of the old animal forms."—

"If animals, from the first appearance of their nascent germs to their full specific maturity, exhibit a cycle of organic changes, what is the beginning of the cycle? What are the conditions of generation? It is the union of a *spermatozoon* with the germinal vesicle of an *ovum*. And these two (the *spermatozoon* and the *ovum*) are the organic products of two perfect animals—male and female. These conditions being satisfied, there commences that cycle of changes, which, however complicated, are *defined by the constant laws of nature*, whereby

two beings are again produced *identical in species* with the two beings from which the two fecundating elements, above-mentioned, were first derived.

"The first set of changes is, in all animals, of the same kind, and consists in the formation of a vital germinal cell, and its propagation of a numerous offspring by repeated spontaneous divisions.... Among the higher vertebrate animals all the derivative germ-cells are employed in the formation of the fœtal tissues and organs, and all the fœtal changes up to the moment of full development are represented in one simple cycle. Not so, if we descend low on the organic scale. *All* the germ-cells are *not* employed in laying down the embryonic tissues. Part o them, with their full spermatic power, are entangled among the tissues, 'and by virtue of their assimilatives and fissiparous forces lay the foundation of a new organism.' (Owen on *Parthenogenesis*, p. 31.) In this way we not merely state a fact, but we give a physiological reason for it (compatibly with elementary vital laws), when we say that a new form of larval life may spring from a previous larva by Parthenogenesis —*i.e.*, without sexual union : but at the same

time by an organic process actually dependent on, and directly derived from, a true sexual union ; out of which union sprang the first larval form in the complicated cycle of changes. Thus a pair of *Aphides* may produce, compatibly with this view, a larval *progeny that is fruitful without any new sexual union*, and this may go on, time after time, till out of *one union* spring a *progeny* amounting to *millions of millions. Still, this cycle of transformed vitality has its termination ;* and *it ends inevitably with a brood of perfect animals*, male and female, of *identical species with the two out of which the cycle was set in its complicated movement. . .* It matters not whether, in speaking of the marvellous transformations in the larval forms of any given species, we tell of *Parthenogenesis* with Owen, or of *Ammen* or *wet-nurses* with Steenstrup. Each set of phenomena is in a true organic cycle, and the perfect animal, with which the cycle ends, is but *a repetition of the same species* with which the cycle started. To this rule there seems to be no exception ; and *the theory of transmutation from one perfect species to another, derives no support from modern Microscopic observations carried on with*

unwearied skill in illustrating the generative progress of the lowest animals on nature's scale."[1]

12. " The experiments of Ehrenberg," observes Professor James Buchanan in his excellent work, *Faith in God,* " instituted with the view of testing the doctrine of spontaneous generation, may be said to have decided the whole question. They show that as far as our clear knowledge extends, the one uniform law, '*Omne vivum ex ovo,*' universally prevails. As the doctrine of spontaneous generation stands opposed to the maxim, that *organic life can be produced only by organic life ;* so the doctrine of a transmutation of species stands opposed to the equally certain maxim, *that like produces like both in the vegetable and animal kingdoms.* There may arise changes of appearance or structure, and some of these changes are transmissible to the offspring, but the mutations thus superinduced are *governed by constant laws, and confined within certain limits."* [2]

13. And now to conclude our list of authorities, we may quote Professor Schultz as deci-

[1] Professor Sedgwick's *Discourse,* pp. 195-199. See also pp. xx. xl.

[2] Professor J. Buchanan's *Faith in God,* vol. i. pp. 451-453.

sively disproving the hypothesis of spontaneous generation by subjecting it to the *experimentum crucis*. Two vessels were filled with distilled water, and in them were placed various animal and vegetable substances. One vessel was left uncovered, the other was firmly closed, and treated by a peculiarly trying process for destroying and excluding all life, by boiling, &c., while the air was renewed in it, after being *filtered* of any germs that might be in it, by passing through a red-hot tube, and strong sulphuric acid. "Thus every living thing," says Schultz, "and all germs in the vessel—all portions of living matter, or of matter capable of becoming animated, were destroyed." The open vessel on the second day contained *Vibriones* and *Monads*, to which were soon added *Polygastrica* and *Rotatoria*. "From the 28th of May till the beginning of August," says Schultz, "I watched the closed vessel, *without being able, by the aid of the Microscope, to perceive any living animal or vegetable substance.* When at last, I separated the different parts of the apparatus, *I could not find* in the whole liquid the slightest trace of *Infusoria*, of *Conferva*, or of *Mould*. But all the three presented them-

selves in great abundance a few days after I had left the vessel standing open."[1]

14. The Microscope, then, in its widest range over the vast and varied worlds of organized beings which it submits to our study, gives no support to the philosophers of our day who would persuade us to believe in "*spontaneous generation*," in "*physiological development*," in the "*transmutation of species*," or in "*organic creation by law.*" Whoever receives such unphilosophical hypotheses, can certainly with no propriety be called an "*unbeliever.*" Of him it may rather be said in the words of the London wit of our own century: "Why, he is the most capacious believer that is to be found anywhere! He believes almost more than any other man. He believes in no cause at all; in the existence of all things from all eternity, without any beginning whatever—that they could not be otherwise than as they are!"[2] The minute infusoria itself covers with ridicule the theories of those who would make the genealogical Tree of Creation to take root—spring up—bud—blossom—and bear fruit, after this fashion,—*Fire-*

[1] Pritchard's *History of Infus. Animalcules*, pp. 54-56.
[2] Lord John Russell's *Life of Moore*, vol. vi. p. 284.

Mist! Mucus! Monad! Mussel! Mite! Mammal! Monkey! MAN!!! We prefer to abide by the grand conclusion to which all Nature guides us—that the same creative wisdom which regulates and governs the smallest satellite, and the largest starry world, through boundless space, "has established the same law for the development of every living atom, as is manifested in the largest animal that inhabits this planet."

"The mind indeed enlighten'd from above
Views God in all; ascribes to the grand cause
The grand effect; acknowledges with joy
His manner, and with rapture tastes His style.
But never yet did philosophic tube,
That brings the planets home into the eye
Of Observation, and discovers, else
Not visible, His family of worlds,
Discover Him that rules them; such a veil
Hangs over mortal eyes, blind from the birth,
And dark in things divine. Full often, too,
Our wayward intellect, the more we learn
Of nature, overlooks her Author more;
From instrumental causes proud to draw
Conclusions retrograde, and mad mistake.
But if His Word once teach us, shoot a ray
Through all the heart's dark chambers, and reveal
Truths undiscern'd but by that holy light,
Then all is plain. Philosophy, baptized
In the pure fountain of eternal love,
Has eyes indeed; and viewing all she sees
As meant to indicate a God to man,
Gives *Him* His praise, and forfeits not her own."

CHAPTER VII.

APPLICATIONS OF THE MICROSCOPE.

1. The Microscope has been of inestimable value to the Palæontologist. Who has not been astonished to find that Cuvier, lighting upon a few fossil bones, never before seen by man, lying scattered at Montmartre, could tell to what species of animals each of these bones had belonged, and could reconstruct the animals of which these had formed a part, perhaps at the distance of millions of ages,—and all this with the most perfect success, as was afterwards demonstrated when these fossil animals were found entire? Not less striking have been the skill and the success of Professor Owen, as with a glance of the Microscope at fragments of fossil nail, or tooth, or joint, he has unerringly assigned each fragmentary part to the class of animals to which it belonged. Nothing but this instru-

ment, he himself states, could have conducted him to some of his most remarkable discoveries. By the Microscope alone, it was determined that the Sandstone of Warwickshire, and the "Keuper-Sandstein" of Wirtemberg, were equivalent formations.[1] By the Microscope, it was determined that the teeth in the "Keuper-Sandstein," supposed by Jaeger to belong to a Saurian reptile, by him named *Mastodonsaurus*, or *Phytosaurus*, were really the same as those in the Trias of Warwickshire; that they had belonged to a primeval gigantic Batrachian—*a frog-like animal* of five or six feet long—to which, from its extraordinary teeth, the name *Labyrinthodon* was given; and that this *Labyrinthodon* might almost to a certainty be regarded as the *Cheirotherium* of the Trias in the Stourton quarries of Cheshire, whose strange footprints had so long exercised the skill and ingenuity of the Palæontologist.[2] By the Microscope, the *Basilosaurus*, once the acknowledged monarch of the Saurian tribes, has been de-

[1] Carpenter on the *Microscope*, p. 758.

[2] Owen's *Odontography*, vol. i. pp. 196, 217; Lyell's *Elements*, pp. 335-342; Morris's *British Fossils*, p. 350; Carpenter on the *Microscope*, p. 758.

posed from its throne, but lifted up to a higher family; since now, as the *Zeugledon Cetoides*, it takes its place among the lower orders of the mammalia.[1] By the Microscope, the *Saurocephalus* has been exiled from the class of reptiles to that of fishes;[2] and, by the Microscope, doubts long entertained by the highest authorities as to the affinities and habits of the gigantic *Megatherium* have been satisfactorily determined.[3]

(1.) Nor let it be supposed that such discoveries affect only questions of abstract science. They often stand connected with matters of the highest importance in everyday life. Owen's discoveries supply us with a case strikingly in point. With his Microscope, our distinguished comparative anatomist and palæontologist finally settled a question of vast importance to the financial and commercial interests of a mighty empire. For recently, it was observed that a rock-formation spread extensively over Livonia and Northern Russia, where the relative posi-

[1] Lyell's *Elements*, p. 234.
[2] Morris's *British Fossils*, p. 343.
[3] Hogg on the *Microscope*, p. 375.

tion of the rock to other strata left its own place in the series undetermined, and where the mineral characters seemed so indistinct as to be referrible either to the Old or New Red Sandstone. Was the formation the Old Red Sandstone? Then no coal-measures could be expected below it. Was it the New? Then the precious mineral might exist below the rock. Until the question, New or Old Red Sandstone? was determined, it was unsafe to expend money in mining, otherwise many fortunes might be squandered in Russia, as they had been formerly thrown away in Great Britain, in hopelessly digging for coal beneath the Old Red, or even still more ancient rocks.[1] "There is no science," it is justly remarked by the distinguished author of the *Old Red Sandstone*, "whose value can be adequately estimated by economists and utilitarians of the lower order. Its true quantities cannot be represented by arithmetical figures or monetary tables; for its effects on mind must be as surely taken into account as its operations on

[1] Murchison's *Silurian System*, vol. i. p. 328; *Siluria*, pp. 93, 388.

matter; and what it has accomplished for the human intellect as certainly as what it has done for the comforts of society, or the interests of commerce. Geology, in a peculiar manner, supplies to the intellect an exercise of this ennobling character. But it has also its *cash value.* The time and money squandered in Great Britain alone, in searching for coal in districts where the well-informed geologist could have at once pronounced the search fruitless, would much more than cover the expense at which geological research has been prosecuted throughout the world."[1] From the peculiar circumstances connected with the case to which reference is now about to be made, geology could not determine whether coal was likely to be found or not; but the Microscope, when appealed to, gave a certain answer.

(2.) Sir Roderick Murchison states, that manifestly " the place of the great upper coal-fields of England is unoccupied by any due representative in the Russian empire."[2] But not so, once thought the palæontologists of Russia.

[1] Miller's *Old Red Sandstone*, pp. 227, 228.
[2] *Siluria*, p. 334.

They were disposed to conclude that the great formation, above referred to, was the New Red, for they found in it some gigantic teeth, which they at first concluded must belong to a Saurian reptile, as they bore a very close resemblance to those of crocodiles. But the teeth were submitted to Professor Owen, and, examining them by the aid of the Microscope, he found that they did not belong to the Saurian order, as the Russian palæontologists had unhesitatingly concluded, but to the *Dendrodus, a fish exclusively Palæozoic.* "If other proofs had not been obtained of the age of these deposits, this tooth alone would have decided the question."[1] And the conclusion, thus farther reached, that this extensively deposited formation was the Old Red Sandstone, not only established an important point in geology, but perhaps also saved many a Russian fortune.

(3.) The value of the application of the Microscope did not stop here; for Sir Roderick Murchison adds,—"Whilst we write, Professor Agassiz acquaints us, that availing him-

[1] Murchison's *Russia*, vol. i. pp. 635, 636; Carpenter on the *Microscope*, pp. 757, 758; Agassiz's *Monographie des Poissons Fossiles*, p. 83.

self of the weapons which Professor Owen had so skilfully wielded, he has commenced a series of researches not only into the teeth, but also into the structure of the hard-enamelled bones of the Russian fossil-fish, and by which he will be enabled to show the same distinctions in the other bones of the different genera of this class, which Professor Owen has so successfully established in relation to the bones of the higher orders of animals." In proof of the justice of such an expectation, Sir R. Murchison calls special attention to three diagrams in his great work, *Russia*, representing the distinctive osteological characters of the remarkable genera, *Glyptosteus*, *Chelonichthys*, and *Psammolepis*.[1] Well might Owen declare, while such discoveries were made by the Microscope, that it was indispensable to the Palæontologist.

(4.) A few weeks ago, some fossil remains of a large animal were discovered near to the shore of Stirling. They were embedded in clay at the depth of eight or ten feet from the surface of the ground, at the distance of two or three hundred yards from the Forth, and not

[1] Murchison's *Russia*, vol. i. p. 67; plate ii. 7, 8, 9.

many feet above the present level of the river. The remains are chiefly vertebral; and it is believed that nearly the entire skeleton may yet be found, when, on the subsidence of the water presently covering the spot, the research can be prosecuted and completed. It was concluded that these fossil bones had belonged to a *whale;* but the conclusion was denied by some. To settle the question, the writer of this little work forwarded a fragment, of what he believed to be one of the cartilaginous vertebral disks of a whale, for examination by Professor Quekett of London. Of date 19th Feb. 1858, this distinguished Microscopist thus replies:—

"The piece of bone received this morning is certainly part of an intervertebral disk of a large whale, one which, no doubt, was stranded many years ago. From its size, it probably was a *Rorqual*, which, I think, is the species most commonly cast on shore, at least in the south of England, the Orkney whale not being so large.[1] Had you not told me what you suspected the bone to be, I could have told you at the first glance."

[1] See below, Sect. 3.

2. The instrument is an equally necessary auxiliary to the Botanist. It has aided him to determine many important or curious questions connected with fossil plants. Professor Nicol of Aberdeen, *e.g.*, by subjecting the ashes of a Silurian anthracite, occurring in Peeblesshire, to the Microscope, detects in it minute tubular fibres; and observes, that they seem to indicate a higher class of vegetables than was previously supposed to exist at that period.[1]

(1.) Mr. Hugh Miller notices, that an organism found by him at an early period of his geological discoveries, in a nodule of the ichthyolite beds of Cromarty, although understood by him to be a vegetable remain, was only recently certainly determined to be a true wood. "Though I described it," says he, "in the first edition of my little work on the Old Red Sandstone in 1841, as exhibiting the woody fibre, it was not until 1845, that, with the assistance of the optical lapidary, I subjected its structure to the test of the Microscope. It turned out, as I had anticipated, to be the portion of a tree; and, on my submitting the prepared specimen

[1] *Testimony of the Rocks*, p. 424.

to one of our highest authorities, the late Mr. William Nicol, he at once decided that the 'reticulated texture of the transverse section, though somewhat compressed, clearly indicated a coniferous origin.' A farther interest accompanies the case, viz., that in this specimen the Microscope presented to our view the most ancient of Scottish lignites."[1]

(2.) Those who have not examined, under the Microscope, thin sections of fossil organized matter—very fine slices of vegetable or animal remains—prepared according to the ingenious plan first adopted, and with such success, by the late Mr. Nicol, can have no adequate idea either of the beauty so revealed in these specimens, or of the nature of the evidence supplied for the determination of nice and difficult questions connected with fossil organisms. In a treatise —still unpublished, but destined, we would fondly hope, to be presented to the public eye at no distant period—recently written by the

[1] *Testimony of the Rocks*, pp. 435, 436; *Old Red Sandstone*, p. 134. "One unique specimen, a true wood of the Araucarian family, the oldest which has yet presented its structure to the Microscope."—From seventh edition (1858) of the *Old Red Sandstone*, p. 361.

late distinguished Professor of Natural Science in the New College, Edinburgh, the lamented Dr. Fleming, justice is done to the originality of Mr. Nicol's labours, and to the value of his invention as an aid to palæontological research. "In connection with organic remains," Dr. Fleming writes, "we briefly refer to the discoveries and labours of an individual who contributed towards the elucidation of the intimate structure of recent and fossil organisms to an extent of which few seem to be aware. To the late William Nicol, Esq., Inverleith, Edinburgh, the students of fossil organisms are indebted for the processes by which thin slices of petrifactions can be prepared, so as to permit the application of the Microscope to the examination of their intimate structure. It is to the processes and the manipulations of this observer, that we are indebted for our knowledge of the relation of the fossil-trees of Craigleith and Granton quarries to the firs, or rather to the Araucarias of the present day. Indeed, without borrowing from the resources of Mr. Nicol, the work of Witham on Fossil Vegetables would have possessed little interest,—the *Fossil Flora* would

have been greatly limited, while the *Odontography* might not have had a being."[1]

(3.) The Microscope has unfolded to us the organization of many of those gigantic plants out of which the coal-measures have been elaborated, and enabled us to ascertain that here the huge fern, there the quaintly-sculptured sigillaria, here the stately calamite, there the graceful lepidodendron played their parts, while the wondrous providence of God was, in the depths of past ages, and long before man appeared on the scene, preparing those inestimably precious stores of fuel, which were destined in the future to make our own island the workshop of the world, and to aid in exalting Britain to the foremost place among the nations.

(4.) The author of these pages has lying before him on his table, while he writes, a very minute but instructive proof of the value of the Microscope in the field of botany. In the Crystal Palace Exhibition of 1851, in the West Main

[1] Dr. Fleming's *Lithology of Edinburgh*, pp. 13, 14. Mr. Nicol's valuable collection is in the possession of one who can both appreciate and increase its interest, Alexander Bryson, Esq., Edinburgh.

Avenue, near to the well-known Crystal Fountain, a noble collection of woods from our colonies, called the "Canadian Trophy," attracted much attention. An enormous petrified tree, from Van Diemen's Land, lay at the base of the "Trophy." This trunk was about ten feet high, and three feet in diameter. The exterior was white and glossy, and the interior presented the appearance of opal. On some places of the tree there was a very fine white powdery dust, the *débris* of the petrified wood. The writer carried away a few pinches of this dust, and, after preparing it by the ordinary process, subjected it to the Microscope. Under the glass these scarcely-perceptible particles of dust exhibited the organic structure of the tree, and proved it to belong to the genus Araucaria. Though the tree had been completely converted into silex, yet the original tissues are so perfectly replaced by the silex, that they display the most minute features of the original organization. The characteristic disks or glands, arranged in alternate order, exhibit the well-known marks of the Araucaria. According to Mr. Nicol, the diameter of one of these disks does not exceed

the $\frac{1}{1000}$th part of an inch; whilst the smallest of these again is of enormous size, when compared with the fibres of the partitions bounding the vessels in which they occur.[1]

(5.) The Microscope also pours its light upon another interesting section of wood on the writer's table. Mr. Layard tells us that while pursuing his remarkable discoveries among the ruins of Nineveh, he one day felt the sweet smell of burning cedar. The Arabs had dug a beam of wood from the mounds of Nimroud, and, as the weather was cold, had made a fire to warm themselves. The wood was cedar, and retained all its original fragrance. "It was probably," says Mr. Layard, "one of the very beams which an inscription discovered on the walls mentions as having been brought from the forests of Lebanon by the king who built the edifice."[2] A piece of the cedar, thus strangely disinterred, was sent home to our distinguished India Missionary, Dr. Duff. The specimen in the writer's possession, prepared as a microscopic

[1] Buckland's *Bridgewater Treatise*, vol. i. pp. 484, 487; vol. ii. pl. 56 *a*.

[2] Layard's *Nineveh and Babylon*, p. 357.

object, is only $\frac{2}{10}$ths by $\frac{1}{10}$th of an inch in size, yet under the instrument, it exquisitely represents the partitions of the wood, and the disks in them placed side by side, and not alternately, as in the previously-noticed specimen of the Araucaria.

(6.) In the examination of living plants, the Microscope traverses a boundless field, and unfolds to us, in every spray, and leaf, and flower, examples of previously unimagined and otherwise unseen manifestations of the power, and wisdom, and goodness of Him who created all "from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall." Justly, therefore, does Professor Balfour observe, that the structure of the cells and vessels of plants can only be fully seen by the aid of the Microscope, and that "for this study the Instrument is indispensable.[1]

3. Who would expect that the Antiquarian's researches, as to events in the dark ages, would be facilitated by the Microscope? But so it is. In 1847, Sir Benjamin Brodie asked Mr. Quekett if it was possible to determine

[1] Balfour's *Phyto-Theology*, p. 50-58.

whether skin, that had been exposed to the air for many years, "was human or not?" "If there are any hairs on the skin," was the reply, "their examination under the Microscope will at once determine the question." The answer was tested, and passed through the ordeal with triumph. A tradition long existed at Worcester, that, centuries ago, a man had been seized in the very act of robbing the Cathedral, and that for this sacrilege the offender had been flayed alive, and his skin nailed to the door of the Cathedral. A few years ago, the old doors of the Cathedral being under repair, a portion of skin, with two hairs, was found under the rusty hinges of the door. This skin, to which Sir B. Brodie had referred, was placed under the Microscope, and it at once appeared that the old tradition was true, as the hairs on this fragment of skin were, beyond a doubt, those of a man!

The author of these pages is obligingly informed by Mr. Quekett, that there are no less than three other places where human skin has been proved by the Microscope so to exist, at Copford and at Hadstock (both in Essex), and

at the door of the Treasury chamber in Westminster Abbey. Mr. Quekett farther states, that in January 1858, he has ascertained, by the assistance of the instrument, that certain bones found in a Pict's house in Orkney, were those of a whale; adding, that scarcely a week passes during which he is not called upon to prosecute similar examinations.

4. Is the Chemist, the Merchant, the Parent of a delicate child, anxious to test the purity of arrowroot? The Microscope may unerringly guide him in his inquiries. For, as the hair of every animal differs from that of another,—as the blood of one living creature is unlike that of every other living creature, so the granules of the starch of wheat, rice, potatoes, *tous-les-mois*, tapioca, and arrowroot, all differ in appearance under the Microscope, each presenting its own peculiar form and proportionate size. The Microscope was called in to decide an important question in connexion with these articles, which arose a few years ago. An attempt was then made to import a large quantity of the starch of the *Cassava* or tapioca, which bore a duty, under the name of arrowroot (*ma-*

ranta arundinacea), upon which there was no duty. If the attempt had been successful, the revenue would have been defrauded to a large amount. Government employed a distinguished chemist, Dr. Ure, to examine into the matter, and to ascertain what was the real character of the cargo. *The skill of the chemist failed* to elicit the truth, but Dr. Ure called in the aid of the Microscope, when it was proved that the article was not *arrowroot*, but *tapioca*.[1] Within a few years, the question of the comparative merits and characters of coffee and chiccory was discussed throughout the empire. It formed the subject of debate in Parliament. An examination into the question took place before a Committee of the House of Commons, when three professional men, chemists, declared that *it was impossible to detect chiccory if it was mixed with coffee*. But the Microscope's aid was employed, and wherever the mixture had taken place the fact was at once discovered. Who has looked into the pages and illustrations in the work of Dr. A. H. Hassall on *Food and its Adul-*

[1] Professor Quekett's *Lectures on Histology*, vol. i. pp. 31, 32.

terations, without being struck with the remarkable place the Microscope has occupied on this subject of national interest?

5. The Microscope offers singular advantages to the Anatomist and the Physician. To this instrument, *e.g.*, we owe the first proof seen by the eye of man of the truth of the theory which has immortalized the name of Harvey. He reasoned out the theory of the circulation of the blood, but never *himself saw* blood to circulate. The Microscope shows us the blood as it actually pursues its marvellous course. By examining the veins and arteries of transparent animals, such as the water-newt, eel, and especially the frog, under the Microscope, we can discern the exquisitely beautiful process; and we can scarcely imagine a more striking evidence of the Divine skill manifested in our physical conformation than that which is thus presented to us.

In 1837, M. Audouin announced that the silk-worms, then for years widely perishing in the south of France, were destroyed by the growth of a fungous vegetation in the interior of their bodies; and it appears that the farther propagation of the disease was at that time arrested

by appropriate remedies. "Wherever," says Professor Carpenter, "the precautions obviously suggested by the knowledge of the nature of the disease afforded by the Microscope, have been duly put in force, its extension has been kept within comparatively limited bounds."[1] Professor Goodsir of Edinburgh stated some years ago, that a peculiarly severe and unmanageable affection (*sarcina ventriculi*), was connected with what appeared under the Microscope to be parasitic vegetables of low organization; and Mr. Quekett recently remarked that remedies to destroy vegetable life might probably arrest a complaint hitherto almost always fatal.[2] Dr. Mantell, again, suggests that as the cell is the extreme point to which we can trace the life of animals and vegetables, and that, as their many important processes are performed through the agency of cells, there—in the cell—disease may probably be most early detected, and in the cell, too, remedial measures may be most beneficially employed.[3]

[1] Carpenter on the *Microscope*, p. 377.
[2] Quekett's *Lectures on Histology*, vol. i. pp. 19, 20.
[3] Mantell's *Invisible World*, p. 24.

6. Results still more important, even the honourable name, and the very existence of individuals, have been found to depend upon the testimony of the Microscope; and the Lawyer at the bar, and the Judge on the bench, have found its evidence all-powerful in deciding the most solemn questions. It is to be remembered that, as seen under the Microscope, the hairs and blood-globules (or red corpuscles of blood) of different kinds of animals are very dissimilar. The *smallest* blood-globule is that of the *Java musk deer*, being (on an average) $\frac{1}{12325}$th of an inch; the *largest* is that of the *Proteus*, an animal of the Batrachian family, being $\frac{1}{337}$th of an inch. The average dimension of the blood-globule of a *sheep*, is $\frac{1}{7000}$th—of a *dog*, $\frac{1}{3542}$d—of a *mouse*, $\frac{1}{3814}$th—and of a *man*, $\frac{1}{3200}$th of an inch. Differences in the form and colour, as well as in the size, of blood-globules, assist in the determination of the species to which they belong. There is an equally striking dissimilarity between the hairs of different kinds of animals; and not only does the hair of one species differ from that of another, but in the same species the form of the hair differs in dif-

ferent parts of the body. Professor Quekett observes, that the minute structure of the hair of different species of the same genus or family is so constant, that a practised eye can readily discriminate between them.[1] A specific variety, with a general similarity, has been observed in the hair of sixteen species of the *Bat* tribe. The hair of the *Indian Bat* is well known as one of the most beautiful examples of microscopic illustration. The studies of the Microscope thus ever and anon reveal to us infinite variety, as well as exquisite uniformity, in the very smallest of the works of the Almighty, and suggest the question, "Who can by searching find out God?" The apparently endless diversities of the structure of the parts of animal bodies, as surveyed by the Microscope, have frequently in our own and foreign countries, determined the issues of life and death in cases of the last importance.

(1.) A remarkable instance occurred in France in 1837. A savage murder was committed on a summer's eve, on the edge of one of the forests in Normandy. A labourer, returning from his daily toils, was stricken down by the hand of an

[1] Quekett on the *Microscope*, p. 432.

assassin, and from the nature of the injury inflicted, it was concluded that the deadly blow had been dealt with a hatchet. Another individual had been seen on the same eve, and about the hour of the commission of the dark deed, near to the scene of the murder. Suspicion fell upon him, he was arrested, imprisoned, and in due course, tried. As witness appeared after witness, their evidence brought the foul deed more and more closely home to the accused, and when it was at length proved, that, upon this man's cottage being searched on the very night after the murder, a hatchet with some stains of blood, and with some hairs upon it, had been found in an outhouse—the murmur went round the court that the evidence was complete—the counsel regarded the conviction as certain—the judge seemed ready to pronounce his doom, and the unhappy accused himself felt that he was lost. But in God's good providence one man was there, who had clearly watched the progress of the trial, and who by no means concurred in the otherwise unanimous opinion of the guilt of the pannel. It was M. Orfila, the distinguished toxicologist. He asked leave from the judge to

examine the hatchet; and to such a man as Orfila his request was not refused. Orfila, on submitting the blood and the hairs to the scrutiny of the Microscope, ascertained that the hairs were the hairs of a deer, and the blood the blood of the same animal, which the accused HAD SAID he had found wounded, and had killed with his hatchet, as he returned from his daily toils! Orfila communicated the results of his *microscopic trial*—a thrilling sensation ran through the audience—the counsel were confounded—the judge felt himself constrained, at the eleventh hour, to find that the charge was not proved, and the pannel was released from the bar, and as from under the sharp axe of the guillotine. The worth of the testimony of the Microscope, and the justice of the decision of the court, were soon proved to the satisfaction of all, for the real murderer was thereafter discovered, acknowledged his guilt, and was executed.

(2.) As in this last case the Microscope saved the innocent, so in our own country it has often condemned the guilty. Many melancholy proofs have recently appeared, that unprincipled mem-

bers of society are largely availing themselves of the facilities supplied by our marvellous progress in art and science, for the more daring commission of enormous crime; but, providentially, the same progress in art and science, which aids the criminal in the perpetration of the darkest deeds, assists the law, and in a still higher degree, in detecting the crime, and in bringing the guilty to condign punishment. The Microscope has played a very remarkable part in such cases. A few examples may prove interesting and instructive.[1]

At the Cumberland Spring Assizes, in 1855, an individual named Munroe was tried for the murder of the paymaster of a colliery, who had been waylaid in a lonely spot, robbed of thirty shillings, and deprived of life, his throat being savagely cut from ear to ear. Munroe had been seen about the time of the murder in a field near to the spot; he had changed a half-sovereign soon thereafter, and had attempted to disguise himself, and altogether change his appearance, by employing a blacksmith to cut off the whole of his whiskers. These, and many other striking points of circumstantial evidence,

[1] Chambers's Papers on the *Microscope*.

were deponed to; but, after the trial had proceeded for two days, and many witnesses had appeared, it was felt that the evidence was incomplete and unsatisfactory, though the actual guilt of the pannel could scarcely be doubted. But the Microscope was called into court, and its evidence adduced in support of the charge. A Microscopist had been employed to examine a pair of corduroy trousers and a razor, which belonged to the prisoner at the time of the commission of the murder. The Microscopist deponed, that he found on the trousers *several small spots*, the largest not so large as a swan-shot; that he discovered, by the aid of the eye of the Microscope, that the spots were *blood;* that they were *human blood;* and that these spots of human blood had been *made by small streams of blood "spirting" upward from the divided artery of a living human body.* He farther deponed that particles of soap attached to the spots of blood; that an attempt had been made to wash them out; and that *ink* had been carefully poured over some of them. He declared, in conclusion, that the handle of the razor, which had belonged to the pursuer, was stained with blood, and that *this blood also was human.*

The counsel for the prisoner was prepared to dispute and to demolish all the previous evidence that had been adduced, but all his efforts failed to shake the testimony of the Microscope. A verdict of guilty was returned by the jury, and the prisoner paid the due penalty of his atrocious crime on the gibbet.

(3.) In another case which occurred a few years ago, the question of guilt or innocence hung upon still more doubtful evidence, until the Microscope, bringing its powers to bear upon a few hairs, and upon a few drops of blood, determined a righteous issue. A girl, nine years of age, was found lying dead, her throat cut, in a plantation in Norfolk. Suspicion fell upon the poor murdered girl's mother, who had been seen by several persons to lead her child to that plantation on the day on which the murder was committed. But the accused coolly and confidently maintained her innocence, admitted that she had been with the murdered girl near the spot where she had perished, but declared that the girl had wandered from her side in quest of flowers; and that after long in vain searching for her, she (the mother) had left her child in the wood where her dead body

was afterwards found. No evidence could at first be discovered to support the early suspicion that the mother was a murderess. A long and sharp knife was indeed found upon her, but, after a keen scrutiny, nothing particular was observed about it, except that there were on the handle a few hairs, so very small as to be scarcely visible. "Here is hair on the handle of your knife!" was the remark made to the suspected mother, in whose presence the examination was conducted. "Yes, very likely," was the immediate and composed reply; "and perhaps there is blood on it, too; for, as I returned from the wood, I found a rabbit in a snare, and cut its throat with my knife." The knife was despatched to London for microscopic examination. It was there found that it had been washed. After very minute investigation, it was farther found *that a fluid had penetrated between the horn-handle and the steel-lining. It was blood*, but *certainly not* the blood of a *rabbit*—rather, *apparently, the blood of a human being.* After examining the hairs on the handle, the Microscopist, who had been intentionally kept from all knowledge of the special facts of the case, unhesitatingly declared that

they were *the hairs of a squirrel.* This was a damning fact for the wretched mother; for a tippet hung around her poor child's neck on the day of the murder; over that tippet the weapon which did the cruel deed must have passed; and that tippet was of *squirrel's hair!* On the trial the jury deemed this one fact, in connexion with the circumstantial evidence, so conclusive, as to warrant them in finding the accused guilty; and, before the day of execution, the mother-murderess fully confessed her crime.

> "The times have been
> That when the brains were out the man would die,
> And there an end: but now they rise again
> With twenty mortal murthers on their crowns,
> And push us from our stools: This is more strange
> Than such a murther is."

(4.) In the summer of 1855, a large sum of gold belonging to the Prussian Government was forwarded, packed in a box, along one of the lines of railway in Prussia. On the arrival of the box at its destination, it was found that the gold had been abstracted, and a quantity of sand substituted in its room. The national police detectives were immediately set to work, but all their efforts, backed by all the appliances of the wealth and power of the Government,

failed to lead to any discovery. At first, it was supposed that the *sand* might show at *what station* the robbery had been effected; but there was sand at one station, and sand at another, and sand at all the stations along the railway line; and so the trace seemed lost. But it was shrewdly suggested that the sand in the box should be submitted to the Microscope; and when so examined, this sand was found to contain *a peculiar minute organism.* Specimens of sand were then brought from *all* the railway stations. On being examined, it was found that only the sand of one station contained the peculiar organism discovered in the sand of the box. At this station, then, the robbery must have been committed. The clue thus given was followed up; and as the Microscope brought to light that little organism in the box, so that little organism brought to light the parties who had placed the sand in that box, and committed the robbery.

"It will have blood; they say, Blood will have blood:
Stones have been known to move, and trees to speak;
Augurs, and understood relations, have,
By magot-pies, and choughs, and rooks, brought forth
The secret'st man of blood."

CHAPTER VIII.

APPLICATIONS OF THE MICROSCOPE.

1. WHERE is the use of the Microscope to terminate, whether we regard the past or the present? the domain of air, or earth, or ocean? Lieutenant Maury of the United States Navy, now Superintendent of the National Observatory at Washington, has lately called in this instrument to ascertain the nature of the bed of the Atlantic, and to determine the course of the great Electric Telegraph, shortly destined, we trust, despite of distance, and winds, and waves, to bind the Old and New Worlds closely together, and to place, as far as rapid intelligence is concerned, London and New York by each other's gate and market-place. Could a submarine plateau be found for the bed of the cable from shore to shore? Was that plateau sheltered and safe from the roll of the Atlantic

water, or from the crush of the Arctic iceberg? These questions demanded an immediate and satisfactory answer, in connection with the grand idea of effecting instantaneous communication between the two great nations of the Anglo-Saxon race. But could an answer be obtained?

2. No eye of man had seen that sea-bottom, and it seemed, therefore, as if man would in vain expect the much-desired response. "It was found more difficult to sound out the sea than to gauge the blue ether and fathom the vaults of the sky." But the little eye of the Microscope *has* scanned these otherwise unseen paths, and *reported* to us much of the geography and natural history of these hitherto untrodden and unknown regions; for the dredgings brought up from the Atlantic's most profound depths, and subjected to the scrutiny of the Microscope, are found to consist of the most tender and delicate organisms, lying in their lowly bed all untouched and unscathed by the roll of the raging floods, or the pressure of the huge iceberg, as it floats resistlessly on its southern course from the Arctic circle towards the Equator. There, then, where the Microscope shows us the little

shell or the minute animalcule reposing in tranquillity, may the great cable of the International Telegraph remain all undisturbed, however fiercely the war of the elements may rage above.

3. On this point, the researches and discoveries of Lieutenant Maury are as interesting as they are original. In the second edition of that magnificent volume, Johnston's *Physical Atlas*, published so late as 1856, we read:—"Between Cape Clear, in Ireland, and Cape Race, in Newfoundland, there is said to be a remarkable steppe, or raised bottom, on which the sea is estimated to be probably no more than 10,000 feet in depth."[1] And in a note, it is added,—"This has been, perhaps hastily, called the *telegraphic plateau*, from the projected submarine telegraph across the Atlantic. The distance from shore to shore by the great circle route is 1600 miles" (1640, Maury's [1856] *Physical Geography of the Sea*); "and it is believed, that while the depth is not so great as to prevent the wires from sinking down and resting on it, it is yet sufficient to guard them

[1] *Physical Atlas*, p. 43.

from the disturbing effects of currents or icebergs. But *the number of soundings is not yet sufficient to warrant this deduction.*"[1]

4. More recent investigations, however, set the question finally at rest. In the new edition (the sixth, issued December 1856) of his remarkable work, the *Physical Geography of the Sea,* Lieutenant Maury informs us that the solution of the question has been obtained, mainly through the use of Brooke's Sounding Apparatus and the *Microscope.* Former modes of sounding the depths of the sea, and of bringing up specimens from the bottom, having proved uncertain and unsatisfactory, the idea of a small but strong twine for a sounding-line, and of a cannon ball of 32 or 68 lbs. for a sinker, was suggested. The idea was improved by Mr. J. M. Brooke of the United States Navy, who proposed a contrivance, by which the shot, on reaching the sea-bottom, detaches itself from the line, and sends up a specimen of the bottom; for the shot, having a hole through its centre, is made to run easily on a rod (fixed to the end of the line), which passes through the centre of the

[1] *Physical Atlas,* note, p. 43.

ball, and has a cup at its base with a little soap or tallow on it for causing the specimens to adhere; or, what has been found to answer better, the barrel of a common quill is attached to the bottom of the rod to receive these specimens. Thus the bottom of the North Atlantic Ocean has certainly been reached at the depth of 25,000 feet, and the most delicate specimens safely raised from that depth. "What is to be the use of these deep-sea soundings?" Mr. Maury asks, and quaintly follows it up with Franklin's question, "What is the use of a new-born babe?" These deep-sea soundings, the moment they were announced to the world, assumed a practical bearing in the minds of intelligent men, with regard to the plan of a submarine telegraph across the Atlantic. First, the existence of the great plateau from Cape Clear to Cape Race, never probably at a greater depth than 10,000 or 12,000 feet, was ascertained; and the farther remarkable geographical fact was noticed, that this plateau, now in the sea—now on the dry land—probably encircles the earth. Thus, between 45° and 50° north latitude, we have the British Islands; then on the Conti-

nent, the great watershed between the Arctic Ocean and the south; the Asiatic chain of steppes and mountains crossing that continent from west to east, until it disappears on the shores of the Pacific; the chain of the Aleutian Islands;—and, finally, along America from west to east—the watershed between the streams that run to the north and south!

5. Along this submarine plateau, the Sounding Apparatus of Mr. Brooke brought up "its first trophies" from the bottom of the North Atlantic. They were submitted to an eminent Microscopist of the United States, Professor Bailey of West Point. He at once expressed his surprise and delight. "The bottom of the ocean," he writes to Mr. Maury, "at the depth of *more than two miles, I hardly hoped ever to have a chance of examining;* yet, thanks to Brooke's contrivance, we have it clean and free from grease, so that it can at once be put under the Microscope. I was greatly delighted to find that *all* these deep soundings are filled with microscopic shells; not a particle of sand or gravel exists in them. . . . The results already obtained are of very great interest, and

have many important bearings on geology and zoology."[1]

6. The specimens, "bits of down from the bed of the ocean," gave microscopic *Foraminifera* in abundance; *Diatoms*, *Polycistias*, and *Spongiolites*. "The unabraded appearance of these organisms, and the almost total absence of the mixture of any detritus from the sea, or foreign matter, suggest most forcibly the idea of perfect repose at the bottom of the deep sea." Thus the appearance of these deep-sea remains, under the close examination of the Microscope, appear clearly to warrant the conclusion at which Mr. Maury arrives, as to the soft character of the bottom of the Atlantic, its quiescent state, *and its adaptation for a telegraphic cable.*

But this new and strange field of observation, subjected to the Microscope, might naturally be expected to disclose great truths altogether apart from the conclusions originally sought. So it has turned out. These little mites of organisms seem to form but slender clews for threading nature's mysteries, yet they suggest

[1] Maury's *Physical Geography of the Sea*, pp. 254, 255.

new views concerning the physical economy of earth and ocean, as any one may at once perceive on opening Maury's pages. We shall select one lesson thus taught as to the nature of the great ocean-bed, and the beneficent and wise ends thereby accomplished by Him, who, in the beginning, gathered together the waters into one place. Not only in the Atlantic, but from the Pacific and Coral Seas, have specimens been now brought up, and, on examination, they all tell the same story, namely, that the bed of the ocean is a vast cemetery. "The ocean's bed, wherever Brooke's sounding-rod has touched, is found to be *soft*, consisting almost entirely of the remains of infusoria. . . . Some of the specimens are as pure and free from the sand of the sea as the snow-flake that falls, when it is calm upon the lea, is from the dust of the earth. Indeed they suggest the idea that the sea, like the snow-cloud, with its flakes, in a calm, is always letting fall upon its bed showers of these microscopic shells; and we may readily imagine that the 'sunless wrecks,' which strew its bottom, are, in the process of ages, hid under this fleecy covering, presenting the rounded ap-

pearance which is seen over the body of the traveller who has perished in the snow-storm. The ocean, especially within and near the tropics, swarms with life. The remains of its myriads of moving things are conveyed by currents, and scattered and lodged in course of time all over its bottom. This process, continued for ages, has covered the depths of the ocean as with a mantle, consisting of organisms as delicate as the macled frost, and as light as the undrifted snow-flake on the mountain." What a marvellously wondrous result is effected by the entombment there of these unnumbered myriads of once living things, and by the deep unbroken silence of this universal ocean churchyard! For let us again quote Maury's words, as he is about to close his volume:—" Brooke's sounding-rod has brought up from the depth of more than 2000 fathoms, under the Gulf Stream, the remains of organisms so delicate, yet so perfect, that evidently they had never been rolled along the bottom of the sea by any current. At the depth of 2000 fathoms in the sea, the pressure is 6000 pounds upon a square inch. Suppose we imagine the currents of the Gulf

Stream, where it is four knots the hour, to be 2000 fathoms in depth, and to reach down to the bed of the ocean with that velocity and pressure, *the scouring action of water under such a weight and motion would fret and wear, break and tear up the very bed and bottom of the sea.*"

7. "Many are the great truths of Nature, which, when once suggested, appear so obvious and simple, that we wonder why reason did not suggest them, or common sense point them out before. So it appears with this *cushion of still water, which seems to be everywhere interposed between the bottom of the deep sea and its currents.* We are surprised now that it never occurred to us that it must be so; how, if it were not so, the scouring action of such currents upon the bed of the ocean would have worn it into deep scores, furrows, and gashes, which, the deeper they grow, the faster they would wear, until finally the *solid crust of our planet would have been worn through.* Thus, while the deep places would grow deeper, the shallow places would grow shallower, the proportion of land and water *surface* would be

altered, and thus that beautiful system of terrestrial economy which regulates the amount and kind of work to be performed by every one of the myriads of physical agencies that have been employed, under the guidance of Supreme Intelligence since the beginning, in bringing this world to the state in which we actually find it, would have been marred long ago."[1]—

> "So He ordained, whose way is in the sea,
> His path amid great waters, and His steps
> Unknown; whose judgments are a mighty deep,
> Where plummet of archangel's intellect
> Could never yet find soundings, but from age
> To age let down, drawn up, then thrown again
> With lengthened line, and added weight, still fails,
> And still the cry in Heaven is, "O the depth!"

8. If it is passing strange that the little eye of the Microscope should thus pierce to scenes to which the eye of man never penetrated, and where even the light of the sun never shone, what shall we say if this Instrument can trace the very steps of the wind, and so unfold to us some of those great laws which guide the course of this proverbially fickle element, as certainly

[1] Maury's *Physical Geography of the Sea*, pp. 358, 359.

as the laws of gravitation unerringly direct the heavenly bodies in their orbits? If Lieutenant Maury's theory can be maintained, even this seemingly hopeless achievement has been so far effected. To illustrate thoroughly his process of reasoning, we must at some length state his views, and after all, from lack of the diagrams represented in the *Physical Geography of the Sea*, perhaps very imperfectly succeed in explaining the theory.

9. Currents of air or wind arise, it is well known, from causes which tend to disturb the equilibrium of the atmosphere, such as changes of temperature, or amount of aqueous vapour contained in it. Two adjoining regions being unequally heated, an upper current of air will proceed to the colder region, and an under current in the opposite direction. The difference of temperature between the polar and equatorial regions, amounting to upwards of 82°, of necessity produces a constant exchange of air between them. The cold and dense air of the polar regions seeks to replace the warm rarefied air of the equator, while it again ascends and forms a current towards the poles, in order to restore the

equilibrium.[1] Two systems of currents, an upper and an under, are thus ever travelling between the equator and the poles, and the causes above-mentioned, in connexion with the rotary motion of the earth from west to east, produce permanent north-easterly or south-easterly currents, forming the "magnificent phenomena" of the Trade Winds, perpetually extending round the earth, from the parallels of about 30° north and south, nearly to the equator.

It is evident that these two currents of air, ever pouring from the poles to the equator, *must* return by some channel to the poles, otherwise, as Maury observes, the wind of the polar regions would soon be exhausted, and it would all be piled up about the equator. But if they return from the equator to the poles, two things follow; first, this *return* current must be in a direction *opposite* to that wind the place of which it goes to supply; and, secondly, this return current must be *in the upper regions* of the atmosphere, at least until it has passed over those parallels where the trade-winds are always blowing on the surface, and in a direction contrary to them.

[1] Johnston's *Physical Atlas*, p. 61.

To explain this, and to meet the difficulties connected with these various currents meeting and crossing at the equator, the Calms of Cancer and Capricorn, and the North and South Poles, Maury, with the help of diagrams, traces the course of a *hypothetical* " particle of northern air" (or a particle of air supposed to pass from the north), and follows it in a round from the North Pole, onward across the equator to the South Pole, and back again to the North. This particle of air (" for reasons," says Mr. Maury, " not very satisfactorily explained by philosophers"), instead of proceeding on the surface all the way from the pole to the equator, travels in the upper regions of the atmosphere, until it gets near the parallel 30° N. Here it meets a "*hypothetical particle*," also in the clouds, that is passing in similar fashion from the south toward the pole. Here these two particles must press against each other, and produce a calm (the Calms of Cancer). From *under* this bank of calms, two currents of air are ejected, one toward the equator as the north-east trades, the other toward the pole, as the south-west passage winds. The barometer, it is noticed in support

of these positions, stands higher in this calm region than it does either to the north or south; a proof, Maury remarks, of the *banking up* of the atmosphere here from the meeting of the two currents, and of *pressure* from its *downward* motion.

The imaginary northern particle having passed the calm belt of Cancer, now moves on the *surface*, as the north-east trade wind. As such it proceeds until it arrives near the equator. Here it meets a similar hypothetical particle which has started from the south pole at the same time that the other left the north pole, and which blew as the south-east trade wind. Again then, there must be another collision of winds—a pressure against each other, and another calm ("the belt of the equatorial calms"). Thus these two hypothetical particles pause in their course; then, warmed by the heat of the sun, they begin to ascend. Our imaginary particle (from the north) travels in the upper regions (counter to the south-east trades, which blow at the surface below), until, in nearly 30° s. latitude, it meets another particle from the south pole. As before, they must contend, then pro-

duce a calm (the Calms of Capricorn), when the northern particle will descend, and pass on as a surface wind from the north-west toward the south pole, where it finds a "*vortex*," or calm place, and finally ascends to the higher regions to commence a corresponding course back towards the north.[1]

Having stated his theory, Mr. Maury observes: "As our knowledge of nature and her laws has increased, so has our understanding of many passages in the Bible been improved. The Psalmist called the earth '*the round world*,'[2] yet for ages it was the most damnable heresy for Christian men to say the world is round; and finally, sailors circumnavigated the globe, proved the Bible to be right, and saved Christian men of science from the stake."[3]

[1] In a subsequent part of his volume, Mr. Maury supports his general theory by arguments derived from evaporation—the rainy winds—the dry winds—the supply of moisture afforded by the *waters* on the south of the equator, to the *land* and *rivers* north of the equator. He regards *magnetism* as the motive cause of his hypothetical particles.

[2] Ps. xcvi. 10, in English Church Psalter, '*the round world*;' in the Vulgate, '*orbs terræ*.'—See Isa. xl. 22, '*the circle of the earth*.'

[3] *Physical Geography of the Sea*, p. 79.

"As for the general system of atmospherical circulation," it is added, "which I have been so long endeavouring to describe, the Bible tells it all in a single sentence:—'The wind goeth toward the south, and turneth about unto the north; it whirleth about continually; and the wind returneth again according to his circuits.'" —(See the connection, Eccles. i. 7.) At the point where we have arrived, Maury admits, that while this theory of the winds seems "*highly probable*" from reasoning, proof is still wanting to establish it as *a fact, that the north-east and south-east trades, after meeting and rising up in the equatorial calms, do cross over and take the paths above described*, and represented in his diagrams.

10. He proceeds to adduce the wanting proof, and it is supplied mainly by the testimony of the Microscope.

"Were it possible," he says, "to take a portion of air, representing, as it travels along with the south-east trades, the general course of atmospherical circulation, *and to put a tally on it*, by which we could follow it in its circuits, and always recognise it, then we might hope actually to prove, by evidence the most positive,

the channels through which the air of the trade winds, after ascending at the equator, returns whence it came."

The air is invisible, and even if it could be seen and seized, where is to be found the *tally* that is to be attached to the air? and supposing it to be found, how is it to be placed upon the wings of the wind? The task seems hopeless; and the very expectation utterly Utopian. But it has actually been done. The *Footprints* of the *Wind* may be traced through the region of the clouds. "*Ehrenberg, with his Microscope, has established, almost beyond a doubt, that the air which the south-east trade-winds bring to the equator, does rise up there and pass over into the northern hemisphere.*"[1] "The Microscope, under the eye of Ehrenberg, has enabled us to put *tallies* on the wings of the wind, to learn of them something concerning its circuits."[2]

11. It occurred to Mr. Maury, that as *Infusoria* are found in sea-dust, rain-drops, hail-stones, and snow-flakes, it might be possible to ascertain from what localities these organisms

[1] *Physical Geog. of the Sea*, p. 117. [2] *Ibid.* p. 260.

had been brought. "If by any chance it should turn out that the *locus* of any of the microscopic 'Infusoria,' so falling, could be identified as belonging to regions travelled by the south-east trade-winds in their hypothetical northern course, strength would be added to many "clews which conduct us into the chambers of the wind, and tell whence it cometh, and whither it goeth." In a previous page we have called attention to Ehrenberg's *Passat-Staub und Blut-Regen*, and showed how microscopic infusoria, *certainly originally belonging to South America*, have fallen from the heavens along the western shores of Africa, and the northern shores of the Mediterranean sea.[1] Maury observes that seamen tell us of "red fog," which they occasionally encounter, especially near the Cape de Verd Islands. Elsewhere they meet showers of dust. The Mediterranean precipitation has been called "Sirocco dust," or "African dust," because supposed to come from the deserts of Africa. But this dust, when microscopically examined, is found to consist of organisms whose *habitat* is not Africa, but *South America, and in the south-*

[1] See p. 64.

east trade-wind region of South America! Professor Ehrenberg has examined specimens of sea-dust from the Cape de Verd Islands and neighbourhood, from Malta, Genoa, Lyons, and the Tyrol. Their similarity is as striking as if all the specimens had been taken from the same pile. *Every specimen is found to consist chiefly of South American forms.* How could the wind carry them from South America along this track? Mark the prevailing course of the north-east trade-wind along *the surface* over all this direction. It might carry dust *to* South America—it could not possibly carry any *from* it. The many feathered arrows in Maury's Plate (VIII.) show at a glance, how strongly and steadily the north-east trades bear down on South America to the south of the Calms of Cancer. But the *supposed* course of the south-east trades after they cross the equator, and as they travel northward, would carry the South American organisms directly along all the course in which they have been found—the Cape de Verd Islands, Lyons, Genoa, Switzerland, the Tyrol. For proof, turn again to Maury's Plates (VII. and VIII.); observe how the feathered arrows fly

in clouds from the south-east toward the eastern shores of South America; and then, *mark* how (Plate VII.) the arrows turn to the north-east in their upper current, and bear along the very course—"the track of the *Passat-Staub*"—from which the winds have dropped their infusorial visitors from the New World.

12. Well may Maury conclude that he has established the fact that there is a perpetual upper current of air from South America to North Africa, and that tallies have been put on the air, and labels placed on the wings of the wind, "to tell whence it cometh, and whither it goeth." Thus the winds, uncertain and unstable as they are, would, if we could fully follow them in their circuits, be found as obedient to the laws of God as the planets are in their paths; and would as certainly proclaim to us their Maker's praise, as the morning stars when they "sang together."

Who can tell what achievements are yet in the future of Science, when thus the waves in the lowest depths of Old Ocean, and the fickle winds in their most wayward course through the high heavens, can be called upon to reveal

to us some of Nature's most deeply hidden secrets, and anew to proclaim the power and wisdom and goodness of Him "who walketh upon the wings of the wind, and measureth the waters in the hollow of His hand?"

"Acquaint thyself with God, if thou would'st taste
His works. Admitted once to His embrace,
Thou shalt perceive that thou wast blind before;
Thine eye shall be instructed; and thine heart,
Made pure, shall relish with delight divine
Till then unfelt, what hands divine have wrought.
. . . . . .
The soul that sees Him, or receives sublimed
New faculties, or learns at least to employ
More worthily the powers she own'd before,
Discerns in all things, what, with stupid gaze
Of ignorance, till then she overlook'd,
A ray of heavenly light gilding all forms
Terrestrial, in the vast and the minute;
The unambiguous footsteps of the God
Who gives its lustre to an insect's wing,
And wheels His throne upon a rolling world."

CHAPTER IX.

APPLICATIONS AND CAPABILITIES OF THE MICROSCOPE.

1. In the most recent appliances of the Microscope, we find it, after traversing worlds —after scanning heaven's heights, and fathoming ocean's depths, and digging deep into the bowels of the earth—after penetrating to the remotest past ages, and making us acquainted with many a new form of existence, and many a new race of beings—at length bringing us back to look again on old familiar faces, but in an extraordinary and interesting way:—We allude to the exquisitely beautiful microscopic photographs taken by Mr. Dancer of Manchester.

2. Many as are the portraits of her Majesty Queen Victoria, our beloved Sovereign, we regard as among the most interesting and singular of them all—that little speck, that scarcely

visible point where the Royal Mother sits with her two eldest-born in her arms.

3. What a marvel, again, is that other microscopic photograph, the "Arctic Council," where, on a space not larger than a pin's head, you have thirteen distinct portraits—where, with a table before them, and charts and despatches outspread in their hands, you look upon the great chiefs of the then living Arctic navigators,—Sir Edward Parry, Sir J. C. Ross, Sir J. Back, and others as illustrious, in anxious council, discussing the plan of search for Sir John Franklin, while, on the wall behind, alongside of the likenesses of Captain Fitzjames and Sir J. Barrow, is seen suspended the portrait of the illustrious though ill-fated Franklin himself! "It is indeed marvellous," as Sir D. Brewster remarks, "that 10,000 single portraits could thus be included in *a square* inch;" and that, as he farther suggests, "Microscopic copies of despatches and plans might be transmitted by post, and important secrets placed in spaces not larger than a *full stop*, or a *small blot of ink*."[1]

[1] *Encyclop. Brit.* vol. xiv. p. 802.

4. It was the good fortune of the author of this little work to have a recent opportunity of employing the Microscope in circumstances where its use led to a singular discovery, fraught to one individual at least with intelligence as interesting as it was unexpected. Two or three years ago, a large collection of photographs, taken in the Crimea during the war, was exhibited in Edinburgh. They belonged to Mr. Fenton of London, amounted to about four hundred in number, and represented the most remarkable incidents and personages connected with the Crimean conflict. The writer, in course of an inspection of the photographs, was contemplating with solemnized feelings the memorable scene of Cathcart's Hill, studded with sepulchral monuments, beneath which sleep so many of Britain's noblest sons. As he passed onward from this photograph, his attention was immediately arrested by another, representing a single sepulchral monument. It occurred to him that this monumental stone was, in outline and appearance, exactly like one which he had just seen in the general group of monuments on Cathcart's Hill. He employed

his pocket Microscope to examine and compare these stones in both photographs, when he found that they were representations of the same scene, *one side* of the monumental stone being seen in the one photograph, and the *opposite side* of the stone in the other. But, on the face of the stone singly represented in the second photograph, the writer, by the aid of his Microscope, made a further discovery. He traced on that stone the handwriting of the sun, as, with unerring fidelity, it had painted the original scene on the far-distant shores of the Crimea; for the Microscope revealed letters written by the light of Heaven, which the eye of man had not previously seen. It deciphered in the photograph the name of the noble soldier whose mortal remains the stone covered,—Captain Edward Stanley, who had fallen on the bloody field of Inkermann! When the attention of the party who had charge of the collection was called to the fact, he expressed his mingled surprise and delight in a very marked manner. The cause of his emotion at once appeared, when he stated that, during the period of the exhibition of the photographs in Edin-

burgh, the bereaved widow of Captain Stanley had frequently visited the collection, and, with many a glance at the representation of Cathcart's Hill, had earnestly, but hitherto in vain, inquired if there was any mark by which she could discover her husband's grave? The exhibitor now longed for the next visit, when he could show to the mourner the very spot, with the inscription on its monument, where the dust of the departed lay.

5. While these pages are passing through the press, we read a few sentences of an article which evidently bears the impress of the genius of one who is well known as occupying one of the highest places in the ranks of the men of literature and science of our day. These sentences more than justify our statements regarding the past, and our anticipations of the future results of Microscopic research. "The marvels of animal and animalcular life now disclosed by the Microscope, stamp a high importance upon zoology, and justify us in regarding it as the most progressive of the sciences. The study of the living world, of the hitherto unrecognised tenants of the earth, the ocean, and the air,

must *for centuries to come call forth all the resources of science, and summon to the Microscope intellects of the highest order.* We can hardly look for discoveries of great novelty in the planetary and sidereal systems. Telescopes have nearly reached their limits in point of size, if not in point of perfection, and it would be presumptuous to hope that we shall ever acquire any knowledge of the structure, or of the inhabitants of the worlds above us. The sciences of optics, mechanics, hydrostatics, and pneumatics, have assumed, more or less, a stationary character, and it must, therefore, be from the other departments of knowledge that a rich harvest of discovery is to be realized.

"The Science of Life, however, the abode of instinct and intelligence, has a character essentially nobler than them all. Its objects are infinite in number, and exciting in interest; and it will require ages to discover and to develop the countless organizations of being, and the strange functions of life, yet concealed from our view. The Microscope, imperfect though it be, is the instrument by which these great results will be achieved; and when it has ac-

quired new powers of penetration and enlargement, it cannot fail to reveal to us marvellous secrets, lifting the veil which shrouds the mysteries of our intellectual nature, and throwing light on questions which human reason has not ventured to approach."[1]

6. When such have been the Applications of the Microscope, and such its Revelations, we may be excused for repeating, that in this little instrument we behold one of man's most perfect inventions. Regarded only as a source of innocent recreation, its excellencies are manifold. Rightly used, it might save many a man from passing his hours in listless *ennui*, or in frivolous but degrading amusements. "I have seen," says Mr. Kingsley, "the cultivated man craving for travel, and for success in life, pent up in the drudgery of London work, and yet keeping his spirit calm, and perhaps his morals all the more righteous, by spending over his Microscope evenings which would too probably have gradually been wasted at the theatre."[2] The Microscope especially demands and deserves the

[1] *North British Review*, No. LV. (Feb. 1858), p. 189.
[2] *Glaucus*, p. 49.

patronage of those who would promote the interests of youth, and advance the cause of enlightened education in our land. The Christian poet, in his *Tirocinium*, has not failed to press upon a father

> . . . . . "blessed with any brains,"

the duty and privilege of combining, in the education of his child, the contemplation of the works of the Almighty with the study of the writings of men:

> "To show him in an insect or a flower,
> Such microscopic proofs of skill and power,
> As, hid from ages past, God now displays
> To combat Atheists with in modern days."

It is now indeed felt, with increasing force from day to day, that while the young should especially study the Bible, the study of the Works of God may be most advantageously combined with the study of the Words of God. Both are Jehovah's volumes; and while the Book of Inspiration alone reveals to us the glory of the gracious Redeemer, the Book of Nature especially reveals to us the glory of the Great Creator. And just as, without the Spirit's teaching, no one can savingly read the Scriptures, so we may be excused for remarking, that, without the aid of such instru-

ments as the Telescope and Microscope, no one can adequately read the wonders of Creation and Providence.—" C'est la Bible à la main que nous devons entrer dans le temple auguste de la Nature, pour bien comprendre la voix du Créateur." We believe, accordingly, that the time will come when not only " every one of our more important educational Institutes will have its own Museum," but its own Telescope and Microscope, that the eye of the pupil may from time to time sweep across the firmament of heaven, and survey its vast globes; and turn to the minutest creature in the particle of dust and drop of water; and in them also see mighty worlds, and marvellous races of organized beings.

7. Such an education, rightly conducted, may be blessed for turning the eye of many a young scholar, and of many an advanced saint, not only to the order and beauty and excellence of the Creator's works in this present material world, but upward to the higher things of spiritual life, and onward to the very glories of Immanuel's land.

" What more prepares us for the songs of heaven?
Creation, of archangels is the theme!
What, to be sung, so needful? What so well

Celestial joys prepares us to sustain?
The soul of man, His face design'd to see,
Who gave these wonders to be seen by man,
Has here a previous scene of objects great
On which to dwell; to stretch to that expanse
Of thought, to rise to that exalted height
Of admiration, to contract that awe,
And give her whole capacities that strength
Which best may qualify for final joy.
The more our spirits are enlarged on earth,
The deeper draught shall they receive of heaven."

Compare, under the Microscope, the most exquisite works which the combined wealth and power, skill and taste of man have ever formed, with the tiniest, humblest work of God, and at a glance the amazing difference is seen. Let the keenest-edged razor, or the sharpest-pointed needle that Sheffield ever sent forth, be placed side by side with the sting of wasp or bee, and while the former is seen to be unequal, rough, jagged as file or saw, the latter is found to be inconceivably fine and smooth. Take the rarest web, or the finest lawn that the looms of Glasgow or Manchester ever manufactured, and place it beside the web of the spider, or the thread of the silk-worm; and the difference between the most delicate gossamer and the coarsest cable, or roughest door-

mat, is as nothing, compared with the difference between the workmanship of the human and the insect weaver. Take the most elaborate ornament which the jeweller fashions from gold and silver, from pearl or diamond, and, placed under the Microscope, it is poor, rude, dim, as contrasted with the rainbow colours on shield of beetle, and wing of butterfly; or with the exquisite carving and contour of flower, and insect, and animalcule. Looked at in this light, we find a new meaning in our Saviour's words: "Consider the lilies of the field, how they grow; they toil not, neither do they spin; and yet I say unto you, that Solomon in all his glory was not arrayed like one of these!" We feel a fresh power in the admonition to the Lord's people: "Wherefore, if God so clothe the grass of the field, which to-day is, and to-morrow is cast into the oven, shall he not much more clothe you, O ye of little faith?"

8. Such lessons should at once teach deepest humility to poor ignorant man in his present state; and exalt the conceptions of the child of God as to the glories of his home in a better world. If this world—fallen as it is—is yet so

fair, and so full of the Divine glory, what must be that coming world, which no curse of God has blighted—which no sin of man has ever sullied; and which the Redeemer is now preparing to be the home and the heritage of his people! For if we should ever remember that knowledge, and holiness, and love—things spiritual and not material—are to be the *excelling* glory of that other world, yet who can tell what may be the glory, even in things material, of that New Jerusalem, which the eye of the Seer saw shining with its streets of gold, and its gates of pearl, and its foundations of all manner of precious stones? And this Instrument may at least aid us in attempting to form some faint conception of that *material* glory; for in taking one glance with it at even a small fragment of (copper) pyrites, we have felt as if that one glance gave us a more exalted view of the new heavens and the new earth, than we had ever before received from the richest hue of the flower, or the most dazzling lustre of the diamond, or the varied colours of the rainbow, or the very light of the sun itself! And surely the highest of all lessons should follow. If God's

minutest creatures here are so glorious—and if God's mightiest works—yonder and above—are so excellently glorious, what must be the Goodness, Greatness, Glory of Him who is Maker, Preserver, King and Lord of All, " who is glorious in His holiness, fearful in His praises, ever doing wonders !"

NOTE ON ALTERNATION OF GENERATIONS AND PARTHENOGENESIS.

THE theories of Spontaneous Generation, and of the Progressive Development of animals from lower to higher forms, wage open war with the great truths of Theology, and, as altogether untenable, seem now to be generally opposed by Naturalists. The theories (or theory) of Alternate Generations and Parthenogenesis do not maintain the same hostile attitude to religion; and the final decision regarding them is accordingly of less importance. But they present deep and difficult questions for the consideration of the Naturalist, and seem destined for a time to lead to much discussion and diversity of opinion.

They certainly present to us new and strange modes of reproduction of life. Trembley's researches in connexion with the *Hydra*, gave the first intimation of them, when, in 1744, he apprised the world of its singular and manifold powers of reproduction. "Imagine a lily producing a butterfly, and the butterfly producing a lily, and you would scarcely invent a marvel greater than the production of Medusæ was to its first discoverers. Nay, the marvel must go farther still; the lily must first produce a whole bed of lilies like its own fair self, before giving

birth to a butterfly ; and this butterfly must separate itself into a crowd of butterflies before giving birth to a lily." [1] Trembley's discoveries were followed by the scarcely less astounding revelations of Bonnet as to the production of *Aphides*, or *plant-lice*. The *aphis*, a winged insect, deposits its eggs on the axils of the leaves of plants in the end of summer ; these eggs are hatched in the following spring ; the production is a *wingless*, *sexless* insect. This wingless insect, while a *virgin mother*, produces its young alive with marvellous rapidity, in repeated births, during the course of a few days. Within twenty-one days, one single aphis has been found to produce ninety-five young ones. These wingless aphides (virgins), so produced, give origin to broods of similar wingless aphides, the reproduction going on to the tenth or eleventh generation, until, in the course of a single season, according to Professor Carpenter, no fewer than ten thousand million millions are evolved. In the end, some of these *larval aphides* are fully developed into males and females, through whose agency *ova* are again produced, and the same cycle of development is repeated the following year. Professor Carpenter regards the multiplication by the *larvæ* as a process of *germination*, analogous to the multiplication of cells by sub-division ; while he holds that the true *generative* process, analogous to the *conjugation* of cells, is only performed when perfect aphides of distinct sexes are evolved.[2]

The tabular view which Professor Owen gives of

[1] Lewes's *Sea-Side Studies*, p. 281.

[2] Carpenter on the *Microscope*, pp. 681, 682.

the *viviparous* increase of the aphides, is altogether overwhelming :—

Generation.	Produce.
1st, ...	1 Aphis.
2d, ...	100, a hundred.
3d, ...	10,000, ten thousand.
4th, ...	1,000,000, one million.
5th, ...	100,000,000, one hundred millions.
6th, ...	10,000,000,000, ten billions.
7th, ...	1,000,000,000,000, one trillion.
8th, ...	100,000,000,000,000, one hundred trillions.
9th, ...	10,000,000,000,000,000, ten quadrillions.
10th, ...	1,000,000,000,000,000,000, one quintillion.

If the oviparous be added to the viviparous generation, the result is thirty times greater![1]

Forty years ago, it began to be observed that similar phases of reproduction were to be witnessed in the case of other animals. In 1819, Chamisso (the author of *Peter Schlemil, the Shadowless Man*) observed that the *Salpa*, one of the humblest of Molluscs, perpetuated its race by alternations, and he first gave to such a succession the name, *Alternation of Generations.* When he announced his discovery, Chamisso was "laughed at as a dreamer;" but the accuracy of his statements is now no longer doubted. The *Salpa* is sometimes a *simple*, sometimes a *compound* animal—sometimes existing solitary, like a hermit in a wilderness; at other times in long chains of many individuals, like the associated brotherhood of a thronged city. Each individual, however, is distinct from its brother, and is capable

[1] Owen's *Compar. Anat.*, p 414.

of maintaining a separate existence, if this bond of brotherhood be dissolved. But the grand peculiarity is, that the *solitary* salpa produces *chained* salpæ, and the *chained* salpæ produce the solitary salpa; nay, it has been ascertained, that invariably the *ovum* of one of the chained salpæ produces a solitary animal, while the *ovum* of a solitary salpa produces the compound animal;[1] or, as Chamisso describes it, "A salpa-mother is not like its daughter, or its own mother, but resembles its sister, its granddaughter, and its grandmother."

The process of *alternation* exists among the *Entozoa*. It has recently been established that *Intestinal Worms*, long regarded as specifically or generically distinct, are but one and the same animal. Von Siebold was the first to announce, in 1844, that these creatures assume quite different forms, and possess different habits, according to the kind of animal in which they live. "For example, the microscopic egg or embryo of a *Tœnia*, evolved in the intestinal canal of a dog or cat, if taken with food into the stomach of a rat, finds its way invariably to the liver, and becomes a *Cysticercus;* while, if it be swallowed by a sheep, it travels by some recondite road to the brain, and is transformed into that parasite so fatally known as producing the 'staggers,' *Cœnurus*. Let either of these now, in turn, be swallowed by the carnivorous quadruped, and a *Tœnia* is the invariable result."[2]

In 1856, Von Siebold published an account of experiments with Moths and Bees, in which he main-

[1] Harvey's *Sea-Side Book*, p. 234. [2] Gosse's *Life*, p. 120.

tains that female virgin moths produced eggs, and that these eggs produced young caterpillars ; and that bees, in similar circumstances, produced eggs, which, however, invariably gave existence to *male* bees, the *fertilized* bee-egg alone developing into a *female*, either *worker* or *queen*.[1]

Dr. Lankester stated at the meeting of the British Association, in 1857, that *Parthenogenesis* exists widely in the vegetable kingdom.[2] A remarkable example is said to exist in Kew Garden, where a certain solitary female plant, recently imported, continues to produce descendants yearly, though no male plant has arrived in the land.

Professor Owen thus explains Parthenogenesis. All organisms, plant or animal, originate in a cell. This cell spontaneously divides into two, these two into four, and so on, till, instead of a cell, a mass is present, called the "germ mass." In the animal, the cells are placed side to side, and form what is called the " mulberry mass," each cell carrying with it a portion of the yolk. The " germ mass" evolves the animal, and each cell reproduces the powers and capacities of the primary germ-cell. The cells have become transformed into tissues. But all the progeny of the primary germ-cell are not required for the formation of the body in all animals ; certain of the derivative germ-cells may remain unchanged, and become included in that body which has been composed of their metamorphosed and diversely combined or confluent brethren. So included, any derivative germ-cell may commence and repeat the same processes by

[1] Lewes's *Sea-Side Studies*, p. 290. [2] *Athenæum*, 1857, p 1157.

imbibition, and of propagation by spontaneous fission, as those to which itself owed its origin.

Owen maintains that this constitutes Parthenogenesis. Some of the cells, instead of being transformed into tissues, remain, unchanged as cells, included in the body, where they repeat the original process of sub-division, and produce offspring, as they themselves were produced. Professor Owen also states why this reproduction has its limits. The original cell, by frequent sub-division, gradually loses a portion of its plastic force. If at first starting it had a force of 100, after passing through 50 subdivisions it is reduced to a force of 2. Thus Parthenogenesis is not indefinitely prolonged.

To many, Owen's theory appears as satisfactory as it is ingenious, while others maintain that it leaves the subject unexplained. It may be regarded, therefore, as still *sub judice.*[1]

[1] Owen on *Parthenogenesis;* Lewes's *Sea-Side Studies.*

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